"Strategic Sourcing Management - A Multiple Criteria Decision Support Methodology with TOPSIS"

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“Strategic Sourcing Management - A Multiple Criteria Decision Support Methodology with TOPSIS”

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Dr. Doctor José Luis Gascó Gascó

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Universidad de Alicante
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<tr>
<td>AtO</td>
<td>Assemble-to-order</td>
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<tr>
<td>CoC</td>
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<td>Quality Assurance Agreement</td>
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<td>Quality Management System</td>
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<td>ROI</td>
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<td>R. STAHL</td>
<td>R. STAHL Schaltgeräte GmbH</td>
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¿Deben las empresas realizar actividades y servicios de fabricación e I+D (Investigación y Desarrollo) por su cuenta o subcontratar éstos a proveedores externos? ¿Qué diseños de cadena de suministro (SCD) pueden ser tomados en cuenta por los responsables de toma de decisiones para diseñar la estrategia más adecuada y efectiva para gestionar actividades externas? Hoy en día, la mayoría de los gerentes eligen la opción de subcontratación para obtener resultados a corto plazo y soluciones para los gerentes de línea. ¿Conlleva la opción de subcontratación una ventaja competitiva a largo plazo para las empresas? ¿Qué criterios deben considerarse para evaluar las opciones de fabricación y subcontratación? ¿Cómo pueden los responsables lidiar con los requisitos de oportunidades y riesgos establecidos en la revisión de la normativa ISO 9001: 2015? Todas estas preguntas han dado lugar a una mayor conciencia de la importancia de la toma de decisión entre la realización de actividades de fabricación en la empresa o la subcontratación de éstas, y especialmente del dilema al que se enfrentan las empresas al decidir entre mantener las actividades de I+D y de fabricación en la empresa o subcontratarlas.

Esta tesis presenta los resultados del trabajo de investigación realizado por el autor, con experiencia internacional en los procesos de gestión de abastecimiento estratégico (SSM) y gestión de la cadena de suministro (SCM). SSM examina en detalle las opciones de autoaprovisionamiento y contratación. SSM abarca el proceso de toma de decisiones del abastecimiento estratégico, incluyendo la cadena de suministro (Supply Chain, SC) en términos de competitividad, eficacia y eficiencia. Esta investigación proporciona una metodología de apoyo a la decisión de SSM y SCM que cualquier profesional puede implementar, independientemente del tamaño o sector industrial de la organización. Las decisiones de SCM y SSM son de importancia estratégica para las empresas y deben tomarse de manera estructurada, sistemática y coherente. El objetivo de este estudio es abordar las decisiones de abastecimiento basadas en una Metodología de Decisión de Criterios Múltiples (MCDM) utilizando la lógica subyacente de la Técnica de Preferencia de Orden por Similitud con la Solución Ideal (TOPSIS). El enfoque adoptado en esta tesis es amplio, global y coherente, pero los capítulos son independientes, permitiendo al lector consultar diferentes capítulos según sea necesario. Esta investigación se organiza en siete partes: (1) una revisión de la literatura sobre decisiones de fabricación o compra se realiza en el capítulo “¿Debemos fabricar o comprar? Una actualización y revisión”; (2) un marco para decisiones de fabricación o compra se desarrolla y analiza en el capítulo “Aprovisionamiento estratégico:
desarrollo de un marco progresivo para decisiones de fabricación o compra”; (3) el capítulo "Integración de los aspectos de sostenibilidad en la selección de proveedores basado en el ejemplo de una empresa industrial alemana" presenta una serie de criterios de sostenibilidad verificados a través de un estudio de caso; (4) las prácticas de evaluación de proveedores se resumen y analizan a través de un estudio de caso múltiple en el capítulo "Prácticas de evaluación de proveedores sostenibles en toda la cadena de suministro: un caso múltiple”; (5) se desarrolla un marco para las decisiones de diseños de cadena de suministro en el documento "Exploración de las prácticas de la cadena de suministro sostenible: un estudio de caso en la industria alemana”; (6) Exploración de cómo evaluar los riesgos de la cadena de suministro sostenible (SSCR) utilizando una FMEA aplicada en un estudio de caso en Alemania, y (7) la aplicación de la metodología Six Sigma para reducir los costes originados por los proveedores externos en un estudio de caso.

Esta tesis considera las perspectivas tácticas y estratégicas en relación con las estrategias corporativas e incluye capítulos dedicados sobre cómo configurar una función de abastecimiento estratégico (SS). El texto está enriquecido con gráficos, marcos y ejemplos sólidos de las mejores prácticas de los estudios de caso. Este estudio se basa en las valiosas y esenciales contribuciones de los responsables involucrados en la toma de decisiones y es adecuado para cualquier persona que trabaje en la gestión de compras y suministros, ya que les permite comprender los mecanismos de creación de valor a través del abastecimiento estratégico.

Ciertamente esta tesis proporciona pautas de gestión para ayudar a los tomadores de decisiones a: (1) evaluar si la subcontratación es adecuada para su empresa; (2) determinar exactamente qué productos y servicios subcontratar, y qué tipo de diseño de cadena de suministro es más adecuado para la empresa; (3) determinar las expectativas de desempeño mediante la evaluación de proveedores externos; (4) usar un proceso profesional bien definido para evaluar y seleccionar qué proveedores externos están más cualificados para el trabajo; (5) utilizando un proceso de evaluación de proveedores para supervisar y revisar los riesgos y el desempeño del proveedor; (6) así como la implementación de la metodología Six Sigma para conseguir una mejora de procesos.

Se espera que los hallazgos y métodos discutidos en esta investigación sean de ayuda en muchas otras actividades de fabricación, particularmente cuando se trata de tomar decisiones sobre las ubicaciones de fabricación. El enfoque descrito en esta tesis se centra en cómo elaborar estrategias de abastecimiento, pero puede estandarizarse y aplicarse en muchas ramas diferentes y proporciona directrices claras y prácticas para mejorar la eficacia de la cadena de suministro.

XIV
Una de las principales contribuciones de la investigación es el desarrollo de nuevos marcos basados en conceptos de investigadores pasados en los campos de SSM y SCM y su integración en situaciones de la vida real, apoyando a la comunidad investigadora. La consistencia de los marcos y modelos propuestos, así como su factibilidad y metodología efectiva, se validan y verifican a través de diferentes estudios de caso.
Summary (Overview of the thesis)

Should firms perform manufacturing and R&D (Research and Development) activities and services on their own or outsource them to external providers? Which supply chain designs (SCD) can be taken into account by decision makers in order to design the most suitable and effective strategy to manage external activities? Today, most managers choose the outsourcing option to obtain short-term results and solutions for line managers. Does the outsourcing option entail a long-term competitive advantage for firms? Which criteria must be considered to evaluate insourcing and outsourcing options? How can managers deal with the opportunities and risks’ requirements set out in the ISO 9001:2015 revision? All these questions have resulted in an increasing awareness of the importance of the make-or-buy decision, and especially the dilemma firms face when deciding between keeping R&D and manufacturing activities in the firm or outsourcing them.

This thesis represents the results from a research work conducted by the author, with a proven international experience in Strategic Sourcing Management (SSM) and Supply Chain Management (SCM) processes. SSM examines insourcing and procurement options in detail. SSM covers the Supply Chain (SC) decision making process in terms of competitiveness, effectiveness and efficiency. This research provides an SSM and SCM decision support methodology that any practitioner can implement – whatever the size or industrial type of the organization. SCM and SSM decisions are of critical strategic importance to firms and should be taken in a structured, systematic and consistent manner. This study is intended to address sourcing decisions based on a Multiple Criteria Decision Methodology (MCDM) using the underlying logic of the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). The approach adopted in this thesis is comprehensive, global and coherent, but the chapters are self-standing, enabling the reader to refer to different chapters according to need. This research is organized into seven: (1) a literature review on make-or-buy decisions is conducted and covered in the chapter “Should we make or buy? An update and review”; (2) a framework for make-or-buy decisions is developed and discussed in the chapter “Strategic sourcing: developing a progressive framework for make-or-buy decisions”; (3) the paper “Integration of sustainability aspects in supplier selection based on the example of a German industrial company” presents a series of sustainability criteria to be taken into account concerning the “buy” option through a case study; (4) supplier evaluation practices are summarized and analyzed through a multiple case study in the chapter “Sustainable supplier
evaluation practices across the supply chain: a multiple case”; (5) a framework for SCD decisions is developed in the chapter “Exploring sustainable supply chain practices: a case study from the German industry”; (6) Exploring how to evaluate Sustainable Supply Chain Risks (SSCR) using an FMEA applied in a case study in Germany, and (7) applying Six Sigma methodology for reduction Supplier Cost of Poor Quality (COPQ) in a case study. This thesis considers both tactical and strategic perspectives in connection with corporate strategies and includes dedicated chapters on how to set up a Strategic Sourcing (SS) function. The text is enriched with clear charts, frameworks and solid examples of best practices from the case studies. This study is underpinned by the valuable and essential contributions of the decision makers involved and is suitable for anyone working in procurement and supply management, as it allows them to understand the mechanisms of value creation through strategic sourcing.

Admittedly, it provides managerial guidelines to help decision makers in: (1) evaluating whether outsourcing is right for their firm; (2) determining exactly which products and services to outsource and which kind of SCD is more suitable for their firm; (3) determining performance expectations by evaluating external providers; (4) using a well-defined professional process to evaluate and select which external providers are more qualified for the job; (5) using a professional supplier evaluation process to monitor and review supplier risks and supplier performance; (6) as well as the implementation of the Six Sigma methodology to achieve process improvement.

The findings and methods discussed in this research will hopefully be of help in many other manufacturing activities, particularly when it comes to making choices about their manufacturing capability locations. The approach described in this thesis focuses on how to craft sourcing strategies, but it can be standardized and applied in many different branches and provides clear and practical guidelines for improving supply chain effectiveness.

One of the research’s main contributions is the development of new frameworks based on past researchers’ concepts on the fields of SSM and SCM and their integration into real-life situations, supporting the research community. The consistency of the proposed frameworks and models, as well as their practicability and effectively methodology are validated and verified through different case studies.
INTRODUCTION
1 Introducción

Este capítulo analiza la relevancia práctica y teórica de las decisiones de abastecimiento estratégico y de la cadena de suministro, fundamentalmente: las decisiones sobre selección y evaluación de proveedores, la estrategia de diseño de la cadena de suministro y la evaluación de riesgos en una cadena de suministro sostenible, también establecen el objetivo de la investigación y las preguntas de investigación de esta tesis. A continuación, la metodología de investigación aplicada en esta tesis se describe y posiciona como parte de la teoría científica. Finalmente, la sección 1.5 de este capítulo describe la estructura de la tesis. Este trabajo de investigación es acumulativo, es decir, los resultados detallados de la investigación se presentan en siete artículos, un artículo ya ha sido publicado en la revista European Research on Management and Business Economics (ERMBE), uno ha sido aceptado por la revista Dirección y Organización (DYO) y uno ha sido publicado como capítulo de libro en la editorial Springer Publishing Group. El resto de estos artículos han sido aceptados en la conferencia de management, economía y contabilidad que se celebrará en Berlin del 29 al 31 de Agosto del 2019.

1.1 Marco general de la tesis doctoral (Implicaciones/Relevancia de las decisiones de abastecimiento estratégico y cadena de suministro para la práctica empresarial)

Las preguntas críticas a las que se enfrentan los profesionales a la hora de decidir entre fabricar sus productos o comprarlos a proveedores externos se ha planteado en el pasado por muchos investigadores. Sin embargo, las opciones de abastecimiento híbrido y plural combinadas con una herramienta práctica para su operacionalización no fueron consideradas. De hecho, las empresas buscan obtener una ventaja competitiva (1) evaluando las decisiones de abastecimiento estratégico y delimitando su oferta de otros competidores en el mercado; (2) seleccionando proveedores externos teniendo en cuenta los criterios más relevantes, evaluando posibles oportunidades y riesgos; (3) evaluando y supervisando el rendimiento de los proveedores externos de manera efectiva y eficiente; (4) seleccionando la estrategia de diseño de la cadena de suministro más apropiada; (5) evaluando los posibles riesgos sostenibles de la cadena de suministro, mitigando posibles riesgos y aumentando la capacidad de recuperación de la empresa; y (6) mejorando procesos implementando la metodología Six
Sigma. Mientras que el abastecimiento híbrido se refiere a la adquisición de todo el volumen de compras en un solo modo, exhibiendo características de un modelo "mixto" de gobernanza, el abastecimiento plural se refiere a la combinación de insourcing (recursos internos) y outsourcing (recursos externos) simultáneamente (Parmigiani, 2007; Park y Ro, 2011; Jacobides y Hitt, 2005; Puranam, Gulati y Bhattacharya, 2013). Este modo de gobernanza no fue considerado por muchos modelos desarrollados en el pasado como el diseñado por Cánez, Platts y Probert (2000). El abastecimiento plural, también llamado "abastecimiento concurrente" o "fabricación interna y externa" en la literatura, es ampliamente implementado por los profesionales.

Además de la perspectiva histórica y dicotómica de fabricación o compra, los responsables de la toma de decisiones también deben tener en cuenta los puntos de vista de abastecimiento híbrido y plural, así como la creación de alianzas estratégicas. Según Doz, Prahalad y Hamel (1990), las empresas conjuntas (joint ventures) brindan un acceso rápido y de bajo coste a nuevos mercados al compartir riesgos y al tener acceso a la experiencia de los socios locales. Los profesionales y los encargados de toma de decisiones desean saber qué factores pueden influir en la decisión de una empresa a la hora de comprar un producto o adquirir un servicio en lugar de fabricarlo internamente y cómo deben evaluarse los factores relevantes para tomar la decisión correcta y evitar futuros problemas y costes adicionales. Sin embargo, muchas decisiones de fabricación o compra son instintivas y las empresas continúan tomando decisiones de forma gradual (McIvor, 2013). Las empresas tienen recursos limitados y no pueden permitirse tener todos los recursos de ingeniería y fabricación internamente. Por lo tanto, la toma de decisiones sobre la fabricación “o/y” compra y sus consecuencias han recibido más atención debido a su influencia en el rendimiento de las empresas. Ciertamente, se requeriría un marco actualizado, eficiente, completo y orientado en la práctica para abordar las decisiones de fabricación “o/y” compra sobre I+D o actividades de fabricación basadas en una metodología de estudio de caso. En contraste con la mayoría de los trabajos anteriores, este estudio aborda no sólo los criterios económicos sino también los relacionados con la estrategia a la hora de tomar estas decisiones de una manera estructurada y eficiente.
1.2 Relevancia teórica de decisiones estratégicas de abastecimiento y cadena de suministro

Implicaciones relevantes para los investigadores referentes al abastecimiento estratégico y a la cadena de suministro han sido también explicadas y abordadas. Los temas teóricos y conceptuales que abordan la esencia de las decisiones de SSM y SCM se tratan en siete capítulos, con un enfoque en las decisiones de fabricación o compra, el aprovisionamiento concurrente o las decisiones de fabricación interna y externa, y la implementación de la metodología Six Sigma para mejorar los procesos.

Además del hecho que SSM pretende implementar múltiples estrategias de SC, que van desde la fabricación interna hasta la subcontratación o una combinación de ambas, el SCM es el proceso de gestión de las relaciones, la información y los flujos de materiales desde la contratación hasta los clientes finales (La Londe, 1997). Dentro del SCM participan una red de empresas, tanto en sentido ascendente como descendente, y el cliente final (Christopher, 1992 y Mentzer et al., 2001). Esta tesis se centra principalmente en los procesos de suministro (upstream), dejando los procesos de distribución (downstream) fuera del estudio. Por lo tanto, SSM es parte del proceso de SCM. Sin embargo, ambos conceptos tenían que diferenciarse entre sí para realizar la investigación. La mayoría de los estudios de SCM se enfocaron principalmente en la externalización o subcontratación (compra).

A lo largo de esta tesis, SS se define como la planificación y selección entre insourcing, outsourcing, aprovisionamiento concurrente, etc., dentro del proceso de la cadena de suministro. SS implica planificación estratégica, calificación de proveedores, desarrollo de proveedores, infraestructura de cadena de suministro, SCD y modelos de subcontratación, teniendo también en cuenta la Gestión de Riesgo de Cadena de Suministro Sostenible (SSCRM). El abastecimiento estratégico es un enfoque de SCM que formaliza y desarrolla canales de suministro considerando los costs totales, no sólo el precio de compra del producto o servicio (Kerruish, 2016), que influye en la forma en que se recopila y utiliza la información para que una empresa pueda aprovechar su estrategia consolidada de compras y encontrar las mejores opciones en el mercado.

Los conceptos y temas de SSM y SCM se han desarrollado en gran medida en publicaciones académicas sobre la cadena de suministro y la estrategia de operaciones (enumeradas en la Tabla 2-5 del Apéndice 2-7). Por lo tanto, este capítulo hace referencia a investigaciones esenciales sobre operaciones y estrategias en la cadena de suministro. Cabe señalar que SSM y SCM están relacionados con una serie de flujos de investigación en gestión de operaciones,
gestión de la cadena de suministro, gestión de compras y muchos otros enfoques de abastecimiento. Estas corrientes de investigación se revisan brevemente y se diferencian explícitamente entre SSM y SCM en la Sección 3.2 Revisión de la literatura (abastecimiento estratégico).


Teniendo en cuenta lo dicho anteriormente, los capítulos 2-8 detallan las teorías organizacionales clave que forman la investigación y los modelos de SSM y SCM desarrollados para comprender el abastecimiento estratégico y las operaciones de la cadena de suministro. Una visión integrada de estas teorías se resume en los marcos desarrollados, que contribuyen al desarrollo continuo de las teorías conceptuales y los modelos en los campos de SSM y SCM.

### 1.2.1 Revisión de la investigación sobre las decisiones estratégicas de abastecimiento y cadena de suministro

La revisión de la investigación se divide en dos secciones, una para las decisiones de SSM y otra para las decisiones de SCM. La Tabla 3-4 en el Apéndice I (3.8.2) enumera en detalle la literatura de SSM revisada.

#### 1.2.1.1 Revisión de la investigación sobre SSM (Paper 2/3)

La literatura sobre fabricación o compra ha sido revisada en el pasado. Por ejemplo, Walker (1988) consideró que muchas actividades deberían ser realizadas internamente para evitar riesgos de apropiación, difusión de tecnología y degradación del producto final. En su opinión, la evaluación del riesgo estratégico asociado con la actividad debería ser favorable a la competencia de la organización para realizar la actividad en oposición a la de los proveedores externos. Mientras que Venkatesan (1992) declaró que los procesos de fabricación donde los proveedores externos tienen una ventaja comparativa sobre la empresa deberían ser subcontratados y los procesos y competencias principales deben internalizarse, Welch y Nayak (1992) argumentaron que las actividades o servicios deben ser internalizados siempre que la tecnología y el nivel de madurez de los procesos sea superior en la empresa. Quinn y Hilmer (1994) apoyaron la decisión de subcontratación cuando se requiere una gran

1.2.1.2 Revisión de la investigación sobre SCM (Paper 4/7)

1.2.1.2.1 Selección / evaluación de proveedores externos

Chen, Lin y Huang (2006) presentaron un enfoque difuso de toma de decisiones para abordar el problema de selección y evaluación de proveedores en los sistemas de la cadena de suministro. Ellos propusieron el concepto TOPSIS como modelo de jerarquía MCDM para resolver el problema de selección del proveedor externo. Sevkli et al. (2007) implementaron la metodología del proceso de jerarquía analítica envolvente de datos (DEAHP) para la selección y evaluación de proveedores en un estudio de caso en Beko, en Turquía. Estos autores destacaron la consistencia de este método híbrido en comparación con la metodología AHP. Sin embargo, no tuvieron en cuenta las demandas de actores interesados a la hora de cumplir con las legislaciones ambientales y las responsabilidades sociales. Mientras que Gencer y Gürpinar (2007) desarrollaron un modelo basado en el proceso de red analítica (ANP) para sistematizar las prácticas de selección y evaluación de proveedores, Tsai, Huang y Wang (2008) combinaron los conceptos de ANP y TOPSIS para evaluar el rendimiento de las empresas en temas de responsabilidad civil. TOPSIS es un método de análisis de decisiones de criterios múltiples, que fue desarrollado originalmente por Hwang y Yoon (1981), y mejorado por Yoon (1987) y Hwang, Lai y Liu (1993). TOPSIS se basa en el concepto que la alternativa elegida debe tener la distancia geométrica más corta a la solución ideal positiva.

En contraste, Öztürk y Özçelik (2014) examinaron cómo identificar al mejor proveedor por medio de los principios de sostenibilidad sobre las operaciones de selección y evaluación de proveedores. Estos autores presentaron un análisis de criterios múltiples y un enfoque de solución basado en el método TOPSIS, incluyendo los criterios sostenibles definidos en el método de Triple Bottom Line (TBL). Además, Sarkis y Dhavale (2015) eligieron el enfoque TBL (beneficio, personas y planeta) para crear un marco bayesiano para evaluar proveedores externos. TBL es un método para medir el rendimiento de sostenibilidad desarrollado por Elkington (1994) y perfeccionado por Jackson, Boswell y Davis (2011). TBL es un concepto que enfatiza la importancia y el impacto que la actividad de una empresa tiene en tres áreas: económica, ambiental y social. Si bien el enfoque de Öztürk y Özçelik (2014) empleó una metodología conocida y útil como el concepto TOPSIS, no tuvieron en cuenta los criterios de conformidad estratégica, de recursos y de calidad dentro de su enfoque. Además, Chaharsooghi y Ashrafi (2014) propusieron un modelo de evaluación y selección de proveedores sostenible que combina una versión mejorada de la metodología TBL con la metodología TOPSIS (neofuzzy).

1.2.1.2.2 SCD

A pesar que el dilema al que se enfrentan los profesionales a la hora de elegir entre estrategias de cadena de suministro ágiles (agile) o austeras (lean) ha sido estudiado por muchos investigadores en el pasado, no se han considerado las estrategias híbridas y múltiples que involucran aspectos de sostenibilidad. Mientras que las estrategias híbridas se refieren a la combinación de estrategias ágiles y austeras, las estrategias múltiples resultan del uso simultáneo de los diseños de gestión de la cadena de suministro. Lean SCD se preocupa por eliminar todos los procesos que no agregan valor y, por lo tanto, minimizar los gastos y los tiempos de ciclo (Hines y Rich, 1997), mejorar la calidad y la disponibilidad del producto (Vrijhoef y Koskela, 2000) a través de los flujos ascendentes y descendentes de productos, servicios e información que se interconectan para reducir los gastos y el desperdicio (Vitasek, Manrodt y Abbott, 2005). Mientras que Tasdemir y Gazo (2018) señalaron que existe la necesidad de desarrollar una herramienta versátil que tenga la capacidad de valorar y referenciar la eficiencia y la sostenibilidad de las organizaciones y sus cadenas de suministro, Martínez León y Calvo-Amodio (2017) plantearon la necesidad de un consenso sobre las
definiciones de las cadenas de suministro lean y la sostenibilidad para lograr una integración exitosa.

Agile SCD, por el contrario, se preocupa por la capacidad de reaccionar rápidamente a la demanda volátil y las características del mercado; por lo tanto, se sugiere donde la demanda es volátil y la rapidez es prioridad (Mason-Jones, Naylo y Towill, 2000; Agarwal, Shankar y Tiwari, 2006) (source-to-order and market responsive). Las estrategias híbridas (estrategias SCD leagile) son una combinación de ambas metodologías y han sido discutidas por autores como Beck (2013), Christopher and Towill (2002), Haq y Boddu (2017), Olhager (2003, 2010) y Sun et al. (2008). Haq y Boddu (2017) argumentaron que el paradigma de gestión de la cadena de suministro leagile, que incluye principios lean y agile, ha adquirido una mayor importancia en escenarios gobernados por tendencias de mercado inestables, mayor variedad de productos y fluctuaciones de la demanda.

Mientras que la estrategia basada en el pronóstico prefería las estrategias de fabricación a inventario (make-to-stock, MtS), entrega a pedido (deliver-to-order, DtO) y ensamblaje a pedido (assemble-to-order, AtO), la estrategia orientada a los pedidos del cliente es más adecuada para la fabricación a medida “fabricación a pedido” (make-to-order, MtO), fuente a pedido (source-to-order, StO) e ingeniería a pedido (engineer-to-order, EtO). Dallasega, Rauch y Frosolini (2018) presentaron "un enfoque lean en proyectos de construcción de ingeniería a pedido", por lo que la orden de trabajo se dividió en pequeños lotes, permitiendo una saturación de capacidad óptima y una reducción del tiempo no productivo y desperdiciado. Según Olhager (2010), el punto de desacoplamiento de la orden del cliente (CODP) divide el flujo de material que es impulsado por el pronóstico (ascendente del CODP) del flujo que es impulsado por la orden del cliente (descendente del CODP). Por lo tanto, el inventario de posicionamiento en la cadena de suministro se planifica gradualmente de acuerdo con su nivel con productos terminados y semiacabados, y el inventario de grupos de ensamblaje, componentes y materia prima del nivel 1-n. Se debe aplicar una cadena de suministro lean para la fase anterior, mientras que una cadena de suministro agile sería más adecuada para las operaciones posteriores (Olhager, 2010). Las cadenas de suministro de leagile serían más adecuadas para las operaciones de punto medio del CODP como el SCD de ensamblaje a pedido (assemble-to-order, AtO) (Beck, 2013).

El diseño apropiado de la cadena de suministro debe seleccionarse de manera estructurada, sistemática y consistente. Mientras Kumar BR, Agarwal y Sharma (2016) consideraron los aspectos ambientales en el diseño de estrategias de cadena de suministro basadas en cadenas
de suministro lean, Fathollahi-Fard, Hajiaghaei-Keshteli y Mirjalili (2018) desarrollaron el diseño de una cadena de suministro de ciclo cerrado, estocástico, multiobjetivo con consideraciones sociales. Según ellos, la mayoría de los estudios actuales consideran los aspectos económicos y solamente unos pocos estudios presentan consideraciones sociales a la hora de diseñar una red de cadena de suministro.

1.2.1.2.3 SSCRMM

Behzadi, O'Sullivan, Olsen y Zhang (2018) identificaron la robustez y la resistencia como dos técnicas clave para la gestión de riesgos y sugirieron métricas para medirlas. Estas dos características deben tenerse en cuenta en todos los marcos de evaluación de riesgos. Según ellos, "la robustez es una capacidad para resistir las interrupciones con una pérdida aceptable de rendimiento, mientras que la resiliencia (es decir, los planes de contingencia que reducen el tiempo de recuperación) es el potencial para recuperarse rápidamente de las interrupciones". Mientras Curkovic, Scannell y Wagner (2013) propusieron la FMEA (Modo de fallo y análisis de efectos, Failure Mode and Effect Analysis) como una herramienta para evaluar la gestión de riesgos de la cadena de suministro, Ratnasari, Hisjam y Sutopo (2018) evaluaron la gestión de riesgos utilizando el método de la casa de riesgo (House of Risk, HOR). HOR es una modificación entre los métodos FMEA y HOQ (House of Quality). El modelo se divide en dos etapas, durante la primera etapa se identifican los riesgos y los agentes causantes de riesgo y luego se miden la gravedad y las incidencias para calcular el valor de la Prioridad de Riesgo Agregado. Por lo tanto, se evalúa la robustez. La segunda etapa está destinada a formular y priorizar acciones de mitigación de riesgos y al fortalecimiento de la resiliencia de la empresa para reducir la probabilidad que ocurran agentes de riesgo. Mientras que D'Amore, Mocellin, Vianello, Maschio y Bezzo (2018) propusieron un modelo para optimizar la captura y el secuestro de carbono en Europa, incluido el análisis del riesgo social y las medidas de mitigación del riesgo, Rostamzadeh, Ghorabaee, Govindan, Esmaeili y Nobar (2018) desarrollaron un enfoque integrado de TOPSIS-CRITIC para la evaluación de la gestión sostenible de riesgos en la cadena de suministro (SSCRM). Para la evaluación de los aspectos de sostenibilidad, propusieron tres categorías, principalmente: (1) sostenibilidad organizacional, (2) responsabilidad social, y (3) la sostenibilidad ambiental.

Ciertamente, la probabilidad de interrupción en las cadenas de suministro varía en función de la estrategia de abastecimiento adoptada (fuente única (nacional, extranjera) y dual). Kumar, Basu y Avittathur (2018) afirmaron que la interacción de tres factores importantes (el
potencial del mercado, la ventaja de coste relativo y la probabilidad de interrupción) juegan un papel importante en la dinámica competitiva. El campo SCRM no es nuevo, por lo que muchos investigadores propusieron modelos de SCRM en el pasado (Hallikas, Karvonen, Pulkkinen, Virolainen y Tuominen (2004); Kleindorfer y Saad (2005); Manuj y Mentzer (2008); Tummala y Schoenherr (2011)). Sin embargo, como ya lo señalaron Scannell, Curkovic y Wagner (2013), no lograron encontrar un consenso sobre la base de SCRM.

La complejidad de las decisiones de abastecimiento y de la cadena de suministro se elabora a fondo dentro de esta tesis. Además, ambas decisiones pueden conllevar un compromiso de grandes inversiones para implementar estrategias de abastecimiento y, por lo tanto, son irreversibles a corto plazo. Por consiguiente, deficiencias de los tomadores de decisiones con respecto a las decisiones de abastecimiento son costosas y tienen un impacto negativo en el rendimiento de la empresa, asumiendo la relevancia administrativa y práctica de las decisiones de abastecimiento.

1.2.2 Resumen de la revisión de la literatura y gap de investigación

Como se vio anteriormente, hay una extensa literatura en los campos de SSM y SCM que ha evolucionado rápidamente en la última década. La mayoría de la literatura sobre SCM favorece la opción de subcontratación desde una perspectiva comprador-proveedor (diádica).

Además, gran parte de la literatura está obsoleta, ya que la actualización de varias normativas publicadas en los últimos años, como la ISO 9001, IATF 16969, ATEX 80079-34, ISO 31000, ISO 26000, ISO 45000, ISO 14001 e ISO 50001, no se tuvieron en cuenta.

Como se señaló en la Sección 1.1, los profesionales tienen un interés en la gestión del abastecimiento estratégico y, en consecuencia, la necesidad de orientación sobre las decisiones de SSM y SCM. Además de esto, la literatura de SSM y SCM es aún escasa y una investigación en profundidad es crucial para implementar los requisitos y las pautas establecidas en los estándares enumerados anteriormente.

Hasta la fecha se han estudiado muchas metodologías para apoyar las decisiones en los campos de SSM y SCM. Después de realizar una revisión de la literatura y una serie de entrevistas con profesionales, quedó claro en esta investigación que muchos modelos propuestos no consideraban criterios relevantes, como la sostenibilidad, o un factor de ponderación diferenciado para cada responsable al evaluar las decisiones de SSM y SCM.

Esta tesis trata de llenar este vacío de investigación y ofrece una metodología de soporte para las decisiones de SSM y SCM basada en un modelo propuesto que combina un MCDM con el método TOPSIS para abordar las decisiones de abastecimiento estratégico en la práctica. Sin
embargo, el modelo no representa una metodología de apoyo a la decisión en el sentido clásico. Se observó la necesidad de esta combinación y, por lo tanto, el modelo sugerido se validó en un estudio de caso en una empresa. Además, las variables y los criterios del modelo MCDM se desarrollaron como parte de la investigación.

1.3 Objetivos y preguntas de investigación de la tesis

El objetivo principal de esta investigación es actualizar la literatura anterior en los campos de SSM y SCM, encontrar vacíos y tendencias en la literatura, analizar cualitativamente este campo, evaluar los hallazgos de un conjunto de entrevistas con profesionales del sector y desarrollar los respectivos modelos y marcos agregando nuevos consejos y sugerencias. Se pretende hacer nuevas contribuciones a la literatura actual con el fin de ayudar a académicos y profesionales a abordar las decisiones de gestión de abastecimiento estratégico de una manera eficiente, eficaz y estructurada. Esta investigación está destinada no sólo a proporcionar una revisión de la literatura histórica más completa sobre las decisiones de fabricación o compra, sino también a analizar los determinantes que desencadenan esas decisiones en el marco de SCM.

Otro objetivo de la investigación de esta tesis es el desarrollo de un marco para apoyar las decisiones de aprovisionamiento, que comprende un objetivo de investigación empírico y teórico. El objetivo empírico es ofrecer a los tomadores de decisiones orientación y apoyo en la toma de decisiones en los campos de SSM y SCM, lo cual, a su vez, conduce a tres subobjetivos empíricos. (1) La tesis proporciona un conjunto de variables y criterios relevantes que deben ser considerados por los tomadores de decisiones en los campos de SSM y SCM, que también explican la influencia de estas variables y los criterios sobre los posibles resultados diferenciados. Adicionalmente, (2) esta tesis ofrece una visión general sobre los criterios múltiples que los tomadores de decisiones pueden tener en cuenta con respecto a las decisiones de SSM y SCM. Finalmente, (3) la tesis proporciona a los profesionales una metodología específica de apoyo en la toma de decisiones para abordar las decisiones en los campos de SSM y SCM.

Ciertamente, el objetivo de la investigación teórica es contribuir a un mayor desarrollo de la investigación en los campos de SSM y SCM. Nuevamente, se persiguen tres subobjetivos teóricos. (1) La tesis presenta evidencias empíricas adicionales sobre las variables relevantes y
los criterios a tener en cuenta en la toma de decisiones en los campos de SSM y SCM, y aborda su impacto en los posibles resultados. Además, (2) los resultados descritos sugieren campos adicionales para futuras investigaciones en el soporte de decisiones para problemas MCDM en los campos de SSM y SCM en general. En conclusión, (3) la aplicación de un MCDM con una metodología TOPSIS integra el conjunto de variables y criterios evaluados previamente para las decisiones en los campos de SSM y SCM, representando un avance en el análisis de decisiones en estas áreas.

A través de los objetivos de investigación mencionados anteriormente, la tesis tiene como objetivo responder a las principales preguntas de investigación que se enumeran a continuación.

### 1.3.1 Preguntas tratadas en el Capítulo 2

La principal pregunta de investigación abarca diferentes aspectos sobre el tema general de la investigación. Para una mejor comprensión del problema de investigación y un enfoque de investigación bien estructurado, se agrega una subpregunta a la pregunta de investigación principal.

- **RQ1:** ¿Debemos fabricar o comprar? ¿Qué opción es mejor?
- **RQ1a:** ¿Qué metodología se puede aplicar para tomar decisiones estratégicas de abastecimiento?

### 1.3.2 Preguntas tratadas en el Capítulo 3

Se sugiere una segunda pregunta de investigación principal, dividida en dos subpreguntas más. Las subpreguntas 2a y 2b se refieren a una investigación empírica sobre decisiones en el campo de SSM.

- **RQ2:** ¿Cómo toman las empresas las decisiones de fabricación o compra?
- **RQ2a:** ¿Qué factores y variables son relevantes en la toma de decisiones de abastecimiento estratégico?
- **RQ2b:** ¿Qué circunstancias indican que las decisiones de abastecimiento estratégico son significativas para una empresa?

### 1.3.3 Preguntas tratadas en el Capítulo 4

Se propone una tercera pregunta de investigación principal, dividida en dos subpreguntas.

- **RQ3:** ¿Cómo pueden las empresas realizar una evaluación de proveedores sostenible en la práctica?
RQ3a: ¿Qué áreas están cubiertas por la evaluación de la sostenibilidad en el proceso de compras?
RQ3b: ¿Qué relevancia tiene la evaluación de sostenibilidad en la gestión de compras?

1.3.4 Preguntas tratadas en el Capítulo 5
Se sugiere una cuarta pregunta de investigación principal, dividida en tres subpreguntas.
RQ4: ¿Cómo pueden las empresas diseñar diferentes estrategias en la cadena de suministro?
RQ4a: ¿Qué áreas de gestión de la cadena de suministro son consideradas cuando se diseña una nueva estrategia de cadena de suministro?
RQ4b: ¿Cómo pueden evaluarse los diseños de la cadena de suministro de manera eficiente?
RQ4c: ¿Cómo se pueden ponderar los criterios múltiples para abordar las decisiones de diseño de la cadena de suministro?

1.3.5 Preguntas tratadas en el Capítulo 6
Se propone una quinta pregunta de investigación principal, con dos preguntas secundarias más.
RQ5: ¿Cómo pueden las empresas integrar los aspectos de sostenibilidad en el proceso de selección de proveedores?
RQ5a: ¿Cómo aplican las empresas los criterios de sostenibilidad durante el proceso de selección de proveedores en la práctica?
RQ5b: ¿Cómo pueden los profesionales aplicar aspectos de sostenibilidad en la práctica?

1.3.6 Preguntas tratadas en el Capítulo 7
Se propone una sexta pregunta de investigación principal, con una subpregunta.
RQ6: ¿Cómo valoran y evalúan las empresas los riesgos en la cadena de suministro?
RQ6a: ¿Qué tendencias de toma de decisiones múltiples relacionadas con los criterios se pueden tener en cuenta para evaluar los riesgos de sostenibilidad en la cadena de suministro?

1.3.7 Preguntas tratadas en el Capítulo 8
Se propone una séptima pregunta de investigación principal, con dos subpreguntas.
RQ7: ¿Qué significa el coste de “mala calidad” (COPQ)?
RQ7a: ¿Cómo pueden las empresas eliminar el coste de “mala calidad” (COPQ)?
RQ7b: ¿Se puede aplicar la metodología Six Sigma para mejorar los procesos de SSM y SCM?
Uno de los objetivos de estas preguntas de investigación es analizar qué aplicaciones de las metodologías MCDM ya existen. Las preguntas de investigación tienen como objetivo identificar qué áreas de aplicación en los campos de SSM y SCM y qué problemas de decisión específicos en estas áreas de aplicación ya están cubiertos por las metodologías de MCDM. Los resultados de este paso apoyan la selección de un método MCDM adecuado, combinado con la metodología TOPSIS para resolver las decisiones de SSM y SCM y la implementación de la metodología Six Sigma para mejorar de procesos interdisciplinarios.

1.4 Posicionamiento de la investigación dentro de la teoría científica (metodología de investigación aplicada en la tesis)

El modelo de diseño de investigación científica es la metodología de investigación empleada en esta tesis, ya que el objetivo de esta tesis no es simplemente explorar un fenómeno, sino crear una herramienta de apoyo de decisiones para la práctica empresarial. De hecho, esta investigación busca desarrollar una teoría formal para extraer conclusiones más amplias sobre la herramienta propuesta de apoyo de decisiones en los campos de SCM y SSM y resaltar las posibles oportunidades para futuros estudios.

¿Qué es el modelo de diseño de investigación científica? La investigación científica se origina a partir de la investigación de sistemas de información y se emplea para crear artefactos innovadores que apoyen a las empresas en la práctica (cf. Hevner et al., 2004). Hay principalmente dos modelos de investigación científica (Design Science Research, DSR):

1– Hevner et al. (2004) - DSR en sistemas de información
2– Peffers et al. (2008) - Metodología DSR

Hevner et al. (2004) afirmaron que los artefactos se definen en términos generales como:
- Constructos (vocabulario y símbolos)
- Modelos (abstracciones y representaciones)
- Métodos (algoritmos y prácticas)
- Instanciaciones (sistemas implementados y prototipos)

Peffers et al. (2008) extendieron la definición de Hevner et al. (2004) y agregaron:
- Innovaciones sociales
- Nuevas propiedades de los recursos técnicos, sociales o informativos.
Dado que el objetivo de esta tesis es crear un modelo de decisión para apoyar las decisiones en los campos de SSM y SCM, el enfoque de investigación en el modelo de investigación de diseño científico es adecuado. El modelo de diseño de investigación científico de Peffers et al. (2008) incluye seis pasos:

(1) **Identificación del problema y motivación:** la investigación científica comienza con una descripción y una investigación del problema subyacente, explicando por qué se necesita una contribución para ayudar a resolver este problema. La motivación o la razón en este contexto para contribuir a resolver este problema es la relevancia académica y empírica del problema relacionado con las estrategias de abastecimiento. El resultado es el inicio del estudio (iniciación centrada en el problema). La gestión estratégica de abastecimiento es un proceso preventivo que se enfoca en anticipar y adquirir las necesidades actuales y futuras de una empresa, al mismo tiempo que aumenta los ahorros y minimiza los riesgos de la cadena de suministro. Su objetivo es garantizar una mejora sostenida en el proceso de abastecimiento estratégico en términos de sostenibilidad, calidad, coste y plazos de entrega del servicio prestado. El aprovisionamiento estratégico desempeña un papel importante en el ciclo de compras, ya que se centra en la identificación de información procesable que permita a las empresas estar bien informadas en el momento de la toma de decisiones, llevando a un ahorro de costes acelerado, aumentando el flujo de efectivo, y obteniendo un mayor y sólido rendimiento de la inversión (ROI).

(2) **Definición de los objetivos de una solución:** este paso proporciona una descripción clara del objetivo de la investigación como parte del diseño de la investigación científica. ¿Qué lograría un buen artefacto? Deben explicarse las contribuciones del artefacto para la comunidad científica y el mundo empresarial. Por ejemplo, aumentar la eficiencia del proceso en un 30% o reducir los costes en un 30%. Por lo tanto, el resultado es la solución centrada en el objetivo.

(3) **Diseño y desarrollo:** una vez que se ha establecido la relevancia del problema y el objetivo de la investigación, comienza la fase de diseño. Encontrar el artefacto es el núcleo de la investigación en ciencias del diseño, ya que implica analizar el problema subyacente en detalle y alcanzar una solución a ese problema en la práctica; por ejemplo, al proponer una metodología de apoyo a la decisión o un modelo en los campos de SSM y SCM. El resultado es el diseño y desarrollo (iniciación centrada) de una metodología.

(4) **Demostración:** el artefacto se aplica para demostrar que es útil para resolver el problema en un contexto definido. El resultado es el contexto iniciado.
(5) **Evaluación**: los resultados generados al aplicar el artefacto diseñado deben analizarse a través de una aplicación experimental del artefacto dentro de una simulación para identificar la efectividad y eficiencia del artefacto. Esta tesis propone una metodología, que se valida a través de su implementación en un estudio de casos donde el artefacto preliminar se rediseña continuamente debido a la iteración con la fase de diseño.

(6) **Comunicación**: Los resultados de la investigación se difunden a través de publicaciones académicas y presentaciones en universidades, revistas de prestigio y conferencias de doctorado.

Esta tesis implementa el diseño del proceso de investigación científico descrito anteriormente, puesto que este proceso hace posible desarrollar una metodología de apoyo en la toma de decisiones en los campos de SSM y SCM y, por lo tanto, es consistente con el enfoque de la tesis. El objetivo del trabajo de esta investigación es analizar un problema de decisión específico, concretamente, las decisiones en los campos de SSM y SCM, y aplicar una metodología de apoyo a la decisión adecuada para resolver el problema de manera eficiente. Por lo tanto, la tesis contribuye a la teoría de decisión normativa.

### 1.5 Estructura de la tesis

Para una mejor comprensión de los contenidos de esta tesis, esta sección presenta su estructura general. Esta investigación está estructurada en diez capítulos agrupados en cuatro bloques, concretamente: **introducción** (capítulo 1); **trabajos de investigación** (capítulos 2-8); **conclusiones finales** (capítulo 9); y **apéndices** (capítulo 10). Los documentos adicionales se adjuntan como apéndices en el capítulo 10. La estructura de la tesis se ilustra en la figura 1-1. El capítulo 1 introduce la relevancia gerencial y teórica, así como el gap de investigación y el objetivo de la investigación. Las decisiones en los campos de SCM y SSM son relevantes tanto para el mundo académico como para el mundo empresarial, de ahí su relevancia gerencial y teórica. A continuación, se exponen las preguntas de investigación abordadas en esta tesis y su posición en la teoría científica.

El capítulo 2 realiza una revisión de la literatura de fabricación o compra para aclarar el término “make-or-buy” y las decisiones de “fabricación y compra” sobre la cadena de suministro tal como se entiende en esta tesis. Para llevar a cabo esta revisión de la literatura, se analizan 99 artículos de siete revistas de prestigio en las áreas de Gestión, Negocios e
Investigación de Operaciones. Por lo tanto, este capítulo analiza las tendencias generales actuales en la investigación de SCM y SSM y muestra que estas tendencias fomentan el desarrollo de estrategias de abastecimiento diferenciadas. Además, el capítulo 2 presenta resultados de decisiones de fabricación o compra que no corresponden al enfoque tradicional de fabricación o compra. Luego, las decisiones de “make-or-buy” se evalúan considerando no sólo la mejora de los costes, sino también las razones estratégicas y los recursos limitados de las empresas.

El capítulo 3 desarrolla un marco progresivo para evaluar decisiones de fabricación o compra basado en entrevistas cualitativas con profesionales y los hallazgos obtenidos de un estudio de caso en la empresa, donde se analizan veinticuatro decisiones de fabricación o compra. El marco incluye los principales aspectos de la literatura y las lecciones aprendidas por los profesionales. Además, se especifica la selección de la metodología MCDM para apoyar la operacionalización del marco y se explica el método en sí. Se discuten los principales hallazgos y se resumen las conclusiones y limitaciones del marco.

El capítulo 4 introduce criterios de sostenibilidad para la evaluación de proveedores basados en las directrices de las normativas ISO 26000 e ISO 9001. Se utiliza una metodología de estudio de caso múltiple para comparar resultados de diferentes fuentes aplicando el mismo método. Los hallazgos y contribuciones clave del estudio se describen comparando los resultados obtenidos en el estudio de dos casos (empresas): una con sede en Europa y la otra en Asia. El modelo de decisión propuesto se basa en las metodologías MCMD y TOPSIS, una matriz de comparación por pares (pairwise comparison matrix, PCM) y un proceso de red analítico (ANP).

El modelo sigue una metodología ANP y arroja luz sobre cómo interactúan los principales criterios, subcriterios y alternativas de abastecimiento estratégico. Además, el modelo se valida y verifica a través de un estudio de caso múltiple.

El capítulo 5 discute la eficiencia de las decisiones de Diseño de la Cadena de Suministro (SCD) basadas en un análisis cualitativo en una empresa alemana. Un modelo de decisión de SCD para resolver las decisiones de diseño de la cadena de suministro se propone y valida a través de un estudio de caso. El estudio afirma la necesidad de evaluar diferentes estrategias de la cadena de suministro en función de diferentes factores, concretamente, grupos de productos, grupos de clientes, frecuencia de ventas de productos y valor del producto. Se detallan conclusiones, limitaciones y posibilidades de investigación futuras. Basado en un
proceso de red analítica (ANP), el modelo ayuda a identificar la interacción entre los clusters principales, los subcriterios y los escenarios de SCD.

El capítulo 6 integra los aspectos de sostenibilidad en el proceso de selección de proveedores mediante un estudio cualitativo basado en una empresa alemana. Después de una revisión de la literatura, la metodología propuesta para resolver las decisiones de selección de proveedores, teniendo en cuenta los aspectos de sostenibilidad, se valida y verifica a través de un estudio de caso.

El capítulo 7 tiene como objetivo responder a cómo se evalúan los riesgos de la cadena de suministro sostenible (SSCR). Se desarrolla un proceso de gestión de SSCR basado en la literatura y los resultados de las entrevistas con los responsables de la cadena de suministro. El proceso propuesto sigue las pautas principales descritas en la normativa ISO 31000; el marco propuesto se utiliza junto con un conjunto de herramientas, especialmente un Análisis de Error de Modo de Fallo (FMEA) para evaluar riesgos y un análisis SWOT para evaluar oportunidades y riesgos. Para diseñar un proceso sólido, participan profesionales experimentados en la cadena de suministro de una empresa alemana y proporcionan comentarios y experiencias relevantes de sus lecciones aprendidas. Ciertamente, la implementación del proceso de SSCRM requiere la definición de relevantes indicadores de rendimiento (KPIs) y su supervisión por medio de un sistema de IT adecuado atendiendo a las necesidades de la empresa.

El capítulo 8 tiene como objetivo demostrar la efectividad y eficiencia de la metodología Six Sigma para la mejora de procesos en general, y para la reducción de los costes de “mala calidad” (COPQ) en las áreas de SSM y SCM en particular.

El capítulo 9 presenta las conclusiones y las contribuciones teóricas y empíricas de la tesis, y también analiza sus implicaciones para la práctica empresarial, limitaciones y las posibilidades que ofrece para futuras líneas de investigación.

Finalmente, en el apéndice que se adjunta en el capítulo 10 se incluye información adicional, como reconocimientos, logros, cuestionarios de encuestas, instrucciones de trabajo en la empresa y cuadros adicionales.
Figura 1-1. Estructura de la tesis

Fuente: elaboración propia
1.6 Bibliografía


This chapter discusses the practical and theoretical relevance of SS and SC decisions, mainly; supplier selection and supplier evaluation decisions, the supply chain design strategy and sustainable supply chain risk assessment, also stating the research objective and the research questions of this thesis. Next, the research methodology applied in this thesis is described and positioned as part of the scientific theory. Finally, section 1.5 of this chapter outlines the structure of the thesis. This research work is cumulative, i.e. the detailed research findings are presented in seven papers, one article has been published on the European Research on Management and Business Economics (ERMBE) journal, one article has been accepted by the Dirección y Organización (DYO) journal and one article has been published as a chapter of a book by the Springer Publishing Group. The rest of them have been accepted by the conference on Management, Economics and Accounting, which will take place in Berlin from 29th to 31st August 2019.

1.1 General framework of the doctoral thesis (Managerial relevance of Strategic Sourcing and Supply Chain decisions)

The critical question practitioners face when deciding between manufacturing their own products or buying them from external providers was studied by many researchers in the past. However, they failed to consider hybrid and plural sourcing options combined with a practical tool for their operationalization. In fact, firms seek to gain competitive advantage by (1) assessing strategic sourcing decisions and delimiting their offering from other competitors in the market; (2) selecting external providers taking into consideration the most relevant criteria, assessing possible opportunities and risks; (3) evaluating and monitoring external providers’ performance in an effective and efficient manner; (4) selecting the appropriate supply chain design strategy; (5) assessing potential sustainable supply chain risks, mitigating possible risks and increasing the firm’s resilience; and (6) improving processes by implementing the Six Sigma methodology. Whereas hybrid sourcing refers to procurement of the entire volume from a single mode that exhibits mixed governance characteristics, plural sourcing refers to the combination of insourcing and outsourcing simultaneously (Parmigiani, 2007; Park and Ro, 2011; Jacobides and Hitt, 2005; Puranam, Gulati and Bhattacharya, 2013). This mode of governance was not considered by many frameworks developed in the past like
the one designed by Cánez, Platts and Probert (2000). Plural sourcing, also called “concurrent sourcing” or “make-and-buy” in the literature, is widely implemented by practitioners.

Additional to the historical and dichotomous make-or-buy perspective, decision makers should also take into account the hybrid and plural sourcing views, as well as the creation of strategic alliances. According to Doz, Prahalad and Hamel (1990), joint ventures provide low-cost, fast access to new markets by sharing risks and borrowing expertise from local partners. Professionals and decision makers want to know which factors may influence a firm's decision to buy a part or acquire a service rather than manufacture it internally and how relevant factors should be evaluated in order to take the right decision and avoid future problems and extra costs. However, many make-or-buy decisions are instinctive, and firms continue to make decisions on a piecemeal basis (McIvor, 2013). Firms have limited resources and cannot afford to have all engineering and manufacturing resources in-house. Hence, “make-or-buy and make-and-buy” decisions and their consequences got more attention because of their influence on firms’ performance. Thus, an updated, efficient, comprehensive and practice-oriented framework was required to address “make-or-buy and make-and-buy” for either R&D or manufacturing activities based on an in-firm case study methodology. In contrast to the majority of past works, this study addresses not only economic but also strategic-related criteria to take these decisions in a structured and efficient manner.

**1.2 Theoretical relevance of Strategic Sourcing and Supply Chain decisions**

Important implications for Strategic Sourcing and Supply Chain researchers have also been explained and addressed. Theoretical and conceptual issues that encapsulate the essence of SSM and SCM decisions are covered in seven chapters, with a focus on make-or-buy decisions, concurrent sourcing or make-and-buy decisions, and the implementation of the Six Sigma methodology for process improvement.

Besides the fact that SSM aims at implementing multiple SC strategies, ranging from insourcing to outsourcing or a combination of both, SCM is the process of managing relationships, information and material flows of physical goods from sourcing to end customers (La Londe, 1997). Within the SCM are involved a network of firms, both upstream and downstream and the final customer (Christopher, 1992 and Mentzer et al., 2001). This
research mainly focuses on the supply processes (upstream), leaving the distribution processes (downstream) out of the focus. Thus, SSM is part of the SCM process. However, both concepts had to be differentiated from each other to conduct the research. Most SCM studies focused only on the “buy” approach.

As defined in this thesis, SS means planning and selecting from among insourcing, outsourcing, concurrent sourcing and so forth within the supply chain process. SS involves strategic planning, supplier qualification, supplier development, supply chain infrastructure, and SCD and outsourcing models, also taking into account Sustainable Supply Chain Risk Management (SSCRM). Strategic sourcing is an approach to SCM that formalizes and develops channels of supply at the total cost, not just the product or service purchase price (Kerruish, 2016), influencing the way information is gathered and used so that a firm can leverage its consolidated procurement strategy to find the best options in the market.

The concepts and subjects of SSM and SCM were largely developed in academic publications on supply chain and operations strategy (listed in Table 2-5 of Appendix 2-7). Therefore, this chapter will make reference to essential papers on operations and SC strategies. It should be noted that SSM and SCM are related to a number of research streams in operations management, supply chain management, purchase management and many other sourcing approaches. These research streams are briefly reviewed and explicitly differentiated from SSM and SCM in Section 3.2 Literature review (Strategic Sourcing).


In light of the above, Chapters 2-8 detail key organizational theories that inform SSM and SCM research and models developed to understand strategic sourcing and supply chain operations. An integrated view of these theories is summarized in the developed frameworks, which contribute to the continuous development of conceptual theories and frameworks in the SSM and SCM fields.

1.2.1 Research review on strategic sourcing and supply chain decisions

The research review is split into two sections, one for SSM and the other for SCM decisions. Table 3-4 in Appendix I (3.8.2) lists in detail the SSM literature reviewed.
1.2.1.1 Research review on SSM (Paper 2/3)

Make-or-buy literature has been reviewed in the past. For instance, Walker (1988) considered that activities should be insourced in order to avoid appropriation risks, technology diffusion and end-product degradation. In his view, the assessment of the strategic risk associated with the activity should be favorable to the organisation's competence in performing the activity as opposed to that of suppliers. While Venkatesan (1992) stated that manufacturing processes where external providers have a comparative advantage against the firm should be outsourced and core manufacturing processes should be insourced, Welch and Nayak (1992) argued that activities or services should be insourced whenever the process technology is mature and superior at the firm. Quinn and Hilmer (1994) supported the outsourcing decision when a high need for flexibility is required and insourcing when the need for flexibility is low. According to Apte and Mason (1995), it is necessary to form a strategic partnership with an external provider or invest to acquire the required competence whenever an activity has a high strategic importance and a low relative efficiency. McIvor, Humphreys and McAleer (1997) developed one employing criteria like core competences, capabilities and costs for evaluating make-or-buy decisions. They highlighted the importance of comparing internal and external criteria. On the other hand, Sislian and Satir (2000) developed a sourcing framework based on four factors, which were subcategorised into (1) primary factors, namely competitive advantage and demand flexibility, and (2) secondary factors, which were process capability, process maturity and strategic risks. The same year Cánez, Platts and Probert (2000) developed a make-or-buy framework. McIvor (2009) proposed a TCE-RBV combined theoretical framework and Brewer, Ashenbaum and Carter (2013) validated it and extended it with performance attributes. Recently, Brem and Elsner (2018) proposed a framework with two kinds of make-or-buy decisions: one associated with production and quality and the other with R&D.

1.2.1.2 Research review on SCM (Paper 4/7)

1.2.1.2.1 Supplier Selection/Evaluation

Chen, Lin and Huang (2006) presented a fuzzy decision-making approach to deal with the supplier selection and evaluation problem in supply chain systems. They proposed the TOPSIS concept as a hierarchy MCDM model to solve the external provider selection problem. Sevkli et al. (2007) implemented the data envelopment analytic hierarchy process (DEAHP) methodology for supplier selection and evaluation in a case study at Beko, in
Turkey. They highlighted the consistency of this hybrid method as compared to the AHP methodology alone. However, they did not take into account the demands of various stakeholders to comply with environmental legislations and social responsibilities. Whereas Gencer and Gürpinar (2007) developed a model based on the analytic network process (ANP) to systematize supplier selection and evaluation practices, Tsai, Huang and Wang (2008) combined the ANP and TOPSIS concepts for evaluating the performance of property-liability firms. TOPSIS is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon (1981), with further developments by Yoon (1987) and Hwang, Lai and Liu (1993). TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution (Assari, Mahesh and Assari, 2012). Furthermore, Boran et al. (2009) proposed an intuitionistic fuzzy set for finding the best option of all the feasible alternatives.

In contrast, Öztürk and Özçelik (2014) examined how to identify the best supplier by means of sustainability principles for supplier selection and evaluation operations. They presented a multi-criteria analysis and solution approach based on the TOPSIS method and including the sustainable criteria defined in the Triple Bottom Line (TBL) method. Also, the TBL (profit, people and planet) approach was chosen by Sarkis and Dhavale (2015) to create a Bayesian framework for evaluating external providers. TBL is a method for measuring sustainability performance developed by Elkington (1994) and perfected by Jackson, Boswell and Davis (2011). TBL is a concept that emphasizes the importance and impact that the activity of a firm has in three areas: economic, environmental and social. Although Öztürk and Özçelik’s (2014) approach employed a well-known and useful methodology like the TOPSIS concept, they failed to consider strategic, resource and quality conformance criteria within their approach. Furthermore, Chaharsooghi and Ashrafi (2014) proposed a sustainable supplier selection and evaluation model combining an improved version of the TBL methodology with the neofuzzy TOPSIS methodology.

### 1.2.1.2.2 SCD

Even though the dilemma faced by professionals when it comes to choosing between agile or lean supply chain strategies has been studied by many researchers in the past, hybrid and multiple strategies involving sustainability aspects have not been considered. Whereas hybrid strategies refer to the combination of agile and lean strategies, multiple strategies result from the simultaneous use of supply chain management designs. Lean SCD is concerned with
eliminating all the non-value-adding processes and thereby minimizing costs and cycle times (Hines and Rich, 1997), improving the quality and availability of the product (Vrijhoef and Koskela, 2000) through upstream and downstream flows of products, services and information that collaboratively work to reduce cost and waste (Vitasek, Manrodt and Abbott, 2005). Whereas Tasdemir and Gazo (2018) stated that there is a need to develop a versatile tool that has the capability to assess and benchmark efficiency and sustainability of organizations and their supply chains, Martínez León and Calvo-Amodio (2017) posed the need for a consensus on definitions of lean supply chains and sustainability for achieving a successful integration.

Agile SCD, conversely, is concerned with the ability to quickly react to volatile demand and market characteristics; therefore, it is suggested where demand is volatile and speed is the priority (Mason-Jones, Naylo and Towill, 2000; Agarwal, Shankar and Tiwari, 2006) (source-to-order and market responsive). Hybrid strategies (leagile SCD strategies) are a combination of both methodologies and have been discussed by authors like Beck (2013), Christopher and Towill (2002), Haq and Boddu (2017), Olhager (2003, 2010) and Sun et al. (2008). Haq and Boddu (2017) argued that the leagile supply chain management paradigm, which includes both lean and agile principles, has attained greater importance in scenarios governed by unstable market trends, increased product variety and demand fluctuations.

Whereas the forecast-driven strategy preferred the make-to-stock (MtS), deliver-to-order (DtO) and assemble-to-order (AtO) strategies, the customer order-driven strategy is more suitable for the make-to-order (MtO), source-to-order (StO) and engineer-to-order (EtO) supply chain situations. Dallasega, Rauch and Frosolini (2018) presented “a lean approach in engineer-to-order construction projects” whereby the job order was split into small lots, thus allowing for optimal capacity saturation and reduction of non-productive and wasted time.

According to Olhager (2010) the customer order decoupling point (CODP) divides the material flow that is forecast-driven (upstream of the CODP) from the flow that is customer order-driven (downstream of the CODP). Thus, the positioning inventory in the supply chain is planned gradually according to its level with finished, semi-finished goods, and the stockage of assembly groups, components and raw material from tier 1-n. A lean supply chain should be applied for the upstream phase, while an agile supply chain would be more suitable for downstream operations (Olhager, 2010). Leagile supply chains would be more suitable for middle point operations of the CODP like assemble-to-order (AtO) SCD (Beck, 2013).
The appropriate supply chain design should be selected in a structured, systematic and consistent manner. While Kumar BR, Agarwal and Sharma (2016) considered the environmental aspects in the design of supply chain strategies based on lean supply chains, Fathollahi-Fard, Hajiaghaei-Keshteli and Mirjalili (2018) developed a multi-objective stochastic closed-loop supply chain network design with social considerations. According to them, most current studies consider the economic aspects and just a few works present social considerations to design a supply chain network.

### 1.2.1.2.3 SSCRM

Behzadi, O’Sullivan, Olsen and Zhang (2018) identified robustness and resilience as two key techniques for managing risks and suggested metrics for measuring them. These two characteristics should be taken into account in every risk assessment framework. According to them, “robustness is an ability to withstand disruption with an acceptable loss of performance, whereas resilience (i.e. contingency plans that reduce time-to-recovery) is the potential to recover quickly from disruptions”. While Curkovic, Scannell, and Wagner (2013) proposed the FMEA (Failure Mode and Effect Analysis) as a tool to evaluate supply chain risk management, Ratnasari, Hisjam and Sutopo (2018) assessed risk management using the house of risk (HOR) method. HOR is a modification between FMEA and HOQ (House of Quality) methods. The model is split in two stages, during the first stage risks and risk causing agents are identified and then the severity and occurrences to calculate the Aggregate Risk Priority value are measured. Hence, robustness is assessed. The second stage is intended to formulate and prioritize actions of risk mitigation and at strengthening the resilience of the firm to reduce the probability of risk agents to occur. Whereas D’Amore, Mocellin, Vianello, Maschio, and Bezzo (2018) proposed a model for optimising the European carbon capture and sequestration, including societal risk analysis and risk mitigation measures, Rostamzadeh, Ghorabae, Govindan, Esmaeili, and Nobar (2018) developed an integrated fuzzy TOPSIS-CRITIC approach for the evaluation of sustainable supply chain risk management (SSCRM). For the evaluation of the sustainability aspects, they proposed three categories, mainly: (1) Organizational sustainability, (2) social responsibility, and (3) the environmental sustainability.

Admittedly, the probability of disruption on supply chains differs depending on the adopted sourcing strategy (single sourcing (domestic, foreign) and dual sourcing). Kumar, Basu, and
Avittathur (2018) stated that the interplay of three important factors; market potential, relative cost advantage and probability of disruption play an important role in the competitive dynamics. The SCRM field is not new so that many researchers proposed SCRM frameworks in the past (Hallikas, Karvonen, Pulkkinen, Virolainen and Tuominem (2004); Kleindorfer and Saad (2005); Manuj and Mentzer (2008); Tummala and Schoenherr (2011)). However, as already pointed out by Scannell, Curkovic and Wagner (2013), they failed to find a consensus about the basis of SCRM.

The complexity of sourcing and supply chain decisions are thoroughly elaborated within this thesis. Furthermore, both decisions may come with a commitment to high investments for implementing sourcing strategies and are therefore most likely irreversible in the short term. Hence, weak-mindedness of decision makers with respect to sourcing decisions are costly and have a negative impact on firm performance, the managerial and practical relevance of sourcing decisions are assumed.

1.2.2 Summary of the literature review and research gap

As seen above, there is a vast body of SSM and SCM literature which has evolved rapidly in the last decade. Most literature on SCM favors the outsourcing option from a buyer-supplier (dyadic) perspective. Also, much of the literature is outdated, as several standards released in recent years, such as ISO 9001, IATF 16969, ATEX 80079-34, ISO 31000, ISO 26000, ISO 45000, ISO 14001 and ISO 50001, are not taken into account.

As noted in Section 1.1, practitioners have an interest in strategic sourcing management and, accordingly, a need for guidance on SSM and SCM decisions. In addition to this, the SSM and SCM literature is still scarce and in-depth research is crucial in order to implement the requirements and guidelines set out in the standards listed above.

To date, many methodologies have been studied to support SSM and SCM decisions. After a literature review and a set of interviews with practitioners were conducted, it became clear in this research that many proposed models did not consider relevant criteria, like sustainability, or a differentiated weight for each decision maker when assessing SSM and SCM decisions. The thesis at hand tries to fill this research gap and offers a support methodology for SSM and SCM decisions based on a proposed model which combines an MCDM with the TOPSIS method for addressing strategic sourcing decisions in practice. Nevertheless, the model does not represent a decision support methodology in the classic sense. The need for this combination was observed and, therefore, the suggested model was validated in an in-firm
case study. Additionally, the variables and criteria of the MCDM model were developed as part of the research.

1.3 Research objective and research questions of the thesis

The main aim of this research is to update the past literature on SSM and SCM, find gaps and trends from the literature, qualitatively analyze this field, evaluate the findings from a set of interviews with practitioners and develop the respective models and frameworks by adding new hints and making new contributions to the current literature in order to help academics and practitioners address strategic sourcing management decisions in an efficient, effective and structured manner. This research is intended not only to provide a more comprehensive historical literature review about make-or-buy decisions, but also to analyze the determinants triggering those decisions in the framework of SCM.

The primary research objective of this thesis is to develop a framework to support sourcing decisions, which comprises a managerial and a theoretical research objective. The managerial objective is to offer decision makers guidance and support on SSM and SCM decisions, which, in turn, leads to three managerial sub-objectives. (1) The thesis provides a set of relevant variables and criteria to be considered by decision makers in SSM and SCM decisions, also explaining the influence of these variables and criteria on possible differentiated outcomes. Additionally, (2) this thesis gives an overview about the multiple criteria decision makers may take into account regarding SSM and SCM decisions. Finally, (3) the thesis provides professionals with a specific decision-making support methodology for addressing SSM and SCM decisions.

Admittedly, the theoretical research objective contributes to the further development of SSM and SCM research. Again, three theoretical sub-objectives are pursued. (1) The thesis presents further empirical evidence concerning relevant variables and criteria for SSM and SCM decisions and addresses how they impact on possible outcomes. Furthermore, (2) the outlined results suggest further fields for future research in decision support for MCDM problems in SSM and SCM in general. In conclusion, (3) the application of an MCDM with a TOPSIS methodology integrates the previously evaluated set of variables and criteria for SSM and SCM decisions, representing an advance in decision analysis in these areas.
By means of the above-stated research objectives, the thesis aims at answering the main research questions listed below.

1.3.1 **Questions addressed in Chapter 2**

The main research question encompasses different aspects of the overall research problem. For a better understanding of the research problem and a well-structured research approach one sub-question is added to the main research question.

RQ1: Should we make or buy? Which one is better?
RQ1a: Which methodology can be applied to make strategic sourcing decisions?

1.3.2 **Questions addressed in Chapter 3**

A second main research question is suggested, split into two more sub-questions. Sub-questions 2a and 2b are concerned with an empirical investigation of SSM decisions.

RQ2: How do firms take make-or-buy decisions?
RQ2a: Which factors and variables are relevant for strategic sourcing decisions?
RQ2b: Which circumstances indicate that strategic sourcing decisions are meaningful for a firm?

1.3.3 **Questions addressed in Chapter 4**

A third main research question is proposed, split into two sub-questions.

RQ3: How can firms perform a sustainable supplier evaluation in practice?
RQ3a: Which areas are covered by evaluation sustainability in procurement?
RQ3b: How relevant is the evaluation of sustainability in procurement?

1.3.4 **Questions addressed in Chapter 5**

A fourth main research question is suggested, divided into three sub-questions.

RQ4: How can firms design different supply chain strategies?
RQ4a: Which supply chain management areas are covered when a new supply chain strategy is designed?
RQ4b: How can supply chain designs be evaluated in an efficient manner?
RQ4c: How can multiple criteria be weighted for addressing supply chain design decisions?

1.3.5 **Questions addressed in Chapter 6**
A fifth main research question is proposed, with two more sub-questions.
RQ5: How can firms integrate sustainability aspects in the supplier selection process?
RQ5a: How do firms apply sustainability criteria during the supplier selection process in the practice?
RQ5b: How can practitioners apply sustainability aspects in practice?

**1.3.6 Questions addressed in Chapter 7**

A sixth main research question is proposed, with one sub-question.
RQ6: How do firms assess and evaluate Supply Chain Risks?
RQ6a: Which multiple decision-making trends relating to criteria can be taken into account for assessing Sustainable Supply Chain Risks?

**1.3.7 Questions addressed in Chapter 8**

A seventh main research question is proposed, with two sub-questions.
RQ7: What does The Cost of Poor Quality (COPQ) mean?
RQ7a: How do firms can eliminate the Cost of Poor Quality (COPQ)?
RQ7b: Can the Six Sigma methodology be applied to improve SSM and SCM processes?

One of the objectives of these research questions is to analyze which applications of MCDM methodologies already exist. The research questions aim to identify, which application areas in SSM and SCM and which specific decision problems in these application areas are already covered by MCDM methodologies. The results of this step support the selection of a suitable MCDM method combined with TOPSIS methodology for resolving SSM and SCM decisions, and the implementation of the Six Sigma methodology for improvement cross-functional processes.

**1.4 Positioning of research within scientific theory (Research methodology applied in the thesis)**

The design science research model is the research methodology employed in this work, as the aim of this thesis is not purely to explore a phenomenon, but to create a decision support tool for business practice. Indeed, this research seeks to develop a formal theory to draw broader
conclusions about the proposed decision support tool in SCM and SSM and highlight possible opportunities for future studies.

What is Design Science Research (DSR)? Design science research originates from research on information systems and is employed to create innovative artifacts that support firms in practice (cf. Hevner et al., 2004). There are mainly two DSR models:

1– Hevner et al. (2004) – DSR in Information Systems
2– Peffers et al. (2008) – DSR Methodology

Hevner et al. (2004) claimed that artifacts are broadly defined as:
– constructs (vocabulary and symbols)
– models (abstractions and representations)
– methods (algorithms and practices)
– instantiations (implemented and prototype systems)

Peffers et al. (2008) extended Hevner et al.’s (2004) definition and added:
– social innovations
– new properties of technical, social, or informational resources

Since the objective of this thesis is to create a decision model to support SSM and SCM decisions, the research approach in design science research model is suitable. The design science research model by Peffers et al. (2008) includes six steps:

(1) Identifying the problem and motivate: Design science research starts with a description and an investigation of the underlying problem, explaining why a contribution is needed to help solve this problem. The motivation or reason in this context for contributing to solve this problem is the academic as well as managerial relevance of the problem concerning sourcing strategies. The output is the initiation of the study (problem-centered initiation).

Strategic sourcing management is a preemptive process, which focuses on anticipating and acquiring the current and future needs of a firm while increasing savings and minimizing supply chain risks. It aims at ensuring sustained improvement in the strategic sourcing process in terms of sustainability, quality, cost and delivery of service provided. Strategic sourcing plays an important role in the procurement cycle as it focuses on identifying actionable insights that empower firms to take well-informed decisions at the right time, leading to
accelerated cost savings, increasing cash flow and obtaining a better Return on Investment (ROI).

(2) *Defining the objectives of a solution:* This step provides a clear description of the research target in design science research. What would a better artifact accomplish? The contributions of the artifact to academia and business practice must be explained. For instance, increasing process’s efficiency by 30% or reducing costs by 30%. Thus, the output is the objective-centered solution.

(3) *Design and development:* After the relevance of the problem and the research objective have been stated, the design phase starts. Finding the artifact is the core of design science research, as it involves analyzing the underlying problem in detail and reaching a solution to that problem in practice; for instance, by proposing a decision support methodology or a SSM and SCM model. The output is the design and development (centered initiation) of a methodology.

(4) *Demonstration:* The artifact is applied to demonstrate that it is useful for solving the problem in a defined context. The output is the context initiated.

(5) *Evaluation:* the outcomes generated by applying the designed artifact must be analyzed through an experimental application of the artifact within a simulation in order to identify the artifact’s effectiveness and efficiency. This thesis proposes a methodology, which is validated through its implementation in a case study where the preliminary artifact is continuously redesigned because of the iteration with the design phase.

(6) *Communication:* Research results are disseminated through scholarly publications, presentations and communications at universities, prestigious journals and doctoral conferences.

This thesis implements the above-described design science research process, as this process makes it possible to develop a decision support methodology for SSM and SCM and is thus consistent with the approach of the thesis. The research goal of this work is to analyze a specific decision problem, namely SSM and SCM decisions, and apply an appropriate decision support methodology to efficiently solve the problem. Therefore, the thesis contributes to normative decision theory.
1.5 Structure of the thesis

For a better understanding of the contents of this thesis, this section presents its structure at a glance. This research is structured into ten chapters grouped into four blocks, namely: introduction (Chapter 1); research works (Chapters 2-8); final conclusions (Chapter 9); and appendices (Chapter 10). Additional documents are enclosed as appendices in Chapter 10. The structure of the thesis is illustrated in Figure 1-1.

Chapter 1 introduces the managerial and theoretical relevance as well as the research gap and the research aim. SCM and SSM decisions are relevant for both academics and practitioners, hence their managerial and theoretical relevance. Next, the research questions addressed in this thesis and its position in scientific theory are stated.

Chapter 2 performs a make-or-buy literature review on clarifying the term “make-or-buy” and “make-and-buy” decisions on supply chain as understood in this thesis. To carry out this literature review, 99 papers from seven prestigious journals in the areas of Management, Business and Operations Research are analyzed. Therefore, this chapter discusses current general trends in SCM and SSM research and shows that these trends foster the development of differentiated sourcing strategies. Furthermore, Chapter 2 presents make-or-buy decision outcomes that do not correspond to the traditional make-or-buy approach. Then, make-or-buy decisions are assessed considering not only cost improvement, but also strategic reasons and limited resources of firms.

Chapter 3 develops a progressive framework for assessing make-or-buy decisions based on qualitative interviews with practitioners and the findings obtained from an in-firm case study, where twenty-four make-or-buy decisions are analyzed. The framework includes the main strands in the literature and the lessons learned from practitioners. Additionally, the selection of the specific MCDM methodology for supporting the operationalization of the framework is specified and the method itself is explained. The main findings are discussed and the conclusions and limitations of the framework outlined.

Chapter 4 introduces sustainable criteria for supplier evaluation based on the guidelines from the ISO 26000 and ISO 9001 standards. A multiple case study methodology is used to compare results from different sources by applying the same method. The key findings and contributions of the study are described by comparing the results obtained from two firms: one based in Europe and the other in Asia. The proposed decision model is based on the
MCMD and TOPSIS methodologies, a pairwise comparison matrix (PCM) and an analytic network process (ANP).

The model follows an ANP methodology and sheds light on how the main clusters, sub-criteria and strategic sourcing alternatives interact. Additionally, the model is validated and verified through the multiple case study.

Chapter 5 discusses the efficiency of Supply Chain Design (SCD) decisions based on a qualitative analysis of a German firm. An SCD decision model for resolving SCD decisions is proposed and validated through a case study. The study claims the need to evaluate different supply chain strategies depending on different factors, namely: product groups, customer groups, product sales frequency and product value. Conclusions, limitations and future research possibilities are outlined. Based on an analytic network process (ANP), the model helps identify the interplay between the main clusters, sub-criteria and SCD scenarios.

Chapter 6 integrates sustainability aspects in the supplier selection process by means of qualitative study based on a German firm. After a literature review, the proposed methodology to resolve supplier selection decisions, taking account of sustainability aspects, is validated and verified through a case study.

Chapter 7 aims to answer how Sustainable Supply Chain Risks (SSCR) are evaluated and assessed. An SSCR management process is developed based on the literature and the findings from the interviews with supply chain managers. The proposed process follows the main guidelines described in the ISO 31000 standard; the proposed framework is used in conjunction with a set of tools, especially a Failure Mode Error Analysis (FMEA) for evaluating risks and a SWOT analysis for assessing opportunities and risks. In order to design a robust process, experienced supply chain professionals from a German firm are involved and provide relevant feedback from their lessons learned. Admittedly, the implementation of the SSCRM process requires the definition of relevant KPIs and monitoring them via a suitable and adapted IT system depending on the firms’ needs.

Chapter 8 aims to demonstrate the effectiveness and efficiency of the Six Sigma methodology for the improvement of processes in general, and for the reduction of "poor quality costs" (COPQ) in the areas of SSM and SCM in particular.

Chapter 9 presents the conclusions and managerial and theoretical contributions of this thesis; also discussing its limitations and the possibilities, it opens up for future research.
Finally, further information like acknowledgments, accomplishments, survey questionnaires, an in-firm work instruction, and additional charts are attached in the appendix enclosed in Chapter 10.
Figure 1.1. Structure of the thesis

1. Introduction
   1.1 Managerial relevance of strategic sourcing and supply chain decisions
   1.2 Theoretical relevance of strategic sourcing and supply chain decisions
   1.3 Research objective and research questions of the thesis
   1.4 Positioning of research within scientific theory
   1.5 Structure of the thesis

Chapters 2-8. Research works

2. Should we make or buy? An update and review
3. Strategic sourcing: developing a progressive framework for make-or-buy decisions
4. Sustainable supplier evaluation practices across the supply chain: a multiple case study
5. Exploring sustainable supply chain practices: a case study from the German industry
6. Integration of sustainability aspects in the supplier selection process: a case study
7. How to evaluate sustainable supply chain risks? A case study from the German industry
8. Applying Six Sigma for reduction supplier Cost of Poor Quality (COPQ): a case study

9. Conclusion and implications
   9.1 Contribution of this thesis
   9.2 Limitations of this thesis and future research

10. Appendix

Source: own source
1.6 References


Publishing.


SHOULD WE MAKE OR BUY?
AN UPDATE AND REVIEW
2. Should we make or buy? An update and review (Art. 1)

Abstract:
Whether firms should perform manufacturing activities on their own or buy them from an external provider is a strategic question that many experts from all firm areas have historically asked themselves. The present paper seeks to address this question by developing a theoretical framework which can help experts evaluate sourcing decisions. After discussing a make-or-buy literature review on 7 prestigious academic journals, the most relevant determinants and theories supported from the literature are identified and illustrated within this framework. The results are subsequently outlined, this research work concluding with a reflection on the extent to which this paper can improve the academic understanding of make-or-buy approaches. The results suggest that practitioners should combine the resource-based view, strategic management and transaction cost economics theories in order to assess manufacturing location decisions.

Keywords: make-or-buy, decision-making, insourcing-or-outsourcing, plural/hybrid sourcing, literature review

JEL Codes: M11, L23, L24.

2.1 Introduction

Even though the dilemma faced by managers when it comes to choosing insourcing or outsourcing specific products or services was studied by many researchers in the past, they failed to consider hybrid and plural sourcings. Whereas hybrid sourcing refers to the procurement of the entire volume from a single mode that exhibits mixed governance, plural sourcing results from the simultaneous use of insourcing and outsourcing (Parmigiani, 2007; Park and Ro, 2011; Jacobides and Hitt, 2005; Puranam, Gulati and Bhattacharga, 2013). Not only the historical and dichotomous make-or-buy perspective should be taken into account by decision makers, but also hybrid and plural sourcing views as well as the creation of strategic alliances. Furthermore, a distinction needs to be drawn within make-or-buy decisions manufacturing activities and those associated with research and development (R&D) (Brem and Elsner, 2018).
According to Doz, Prahalad and Hamel (1990), joint ventures provide low-cost, fast access to new markets by sharing risks and borrowing expertise from local partners. Specialists and decision makers want to know both which factors are likely to influence a firm’s decision to buy a specific part or service rather than to produce it internally and how the relevant factors should be evaluated to ensure that the right decision will be made, thus avoiding future problems and extra costs. A number of researchers have argued that quite a few make-or-buy decisions have an instinctive nature or are based on an ad-hoc response –without a predetermined plan– when an obligation exists to reduce cost and/or improve the quality of a product or service (Moschuris, 2007). The staff from R&D and quality departments, in addition to those working for controlling and legal departments, should play a relevant role as well (Brem, Gerhard, and Voigt, 2014). After all, the consequences of make-or-buy decisions can determine the firm’s future.

During the last few decades, academic research on make-or-buy has rapidly evolved favoring above all the outsourcing option. Indeed, the extremely fast growth experienced by the make-or-buy research field has hardly left any room for scholars to carry out a global, thorough assessment of the research activity undertaken to date. This article has as its aim not only to provide a more comprehensive historical literature review about make-or-buy decisions, but also to analyze the determinants triggering those decision within the framework of supply chain management. Furthermore, the goals sought with this study are threefold: examining the extant literature –insofar as it reveals both past and current trends– identifying possible gaps; and offering potential research opportunities for future researchers. The analysis of the literature will identify the most relevant journals in this area, additionally highlighting the most important determinants, as well as the most commonly supported theories and trends in the make-or-buy literature.

### 2.2 Literature review approach (Approach adopted in the literature review)

Our work process began with the systematic identification of renowned academic journals in the field of make-or-buy decisions –also referred to as insourcing or outsourcing decisions in the literature. A search for the keywords “make-or-buy” and “insourcing or outsourcing” in academic databases was performed, following a database search methodology similar to the one adopted by Durst and Edvardsson (2012); and Butkovic, Kauric, and Mikulic (2016). In
particular, this review sought to screen the existing studies (published in the period comprised between 1982 and 2017) by means of three databases –ProQuest, Scopus and Web of Science– chosen because of their strong reputation when it comes to academic articles.

Articles and publications dealing with make-or-buy decisions were listed on a spreadsheet along with some basic information, namely: author; country of origin provenance; topic; and year of publication –with the possibility of including additional comments. An electronic search was completed with a manual one, especially focused on tracing the papers cited in the bibliography of the previously selected articles.

The journals which serve as the basis to analyze the literature revolving around make-or-buy decisions fulfil the requirement of appearing in the databases mentioned above and in the Journal Citation Report (JCR) database. The impact factor index of the reviewed journals is based on the data registered at the JCR published by Thomson Reuters in Q1-2016. The search for make-or-buy papers, which began without limiting their publication date, took place between January and February 2017.

The original sample of 123 articles was reduced to 99 articles, priority being give to articles based on empirical analysis and examinations of the topic over theoretical ones. Only articles from the journals listed in Table 2-1 were included. The aforesaid reduction meant eliminating articles which, by way of example, might have focused on marketing or physics rather than on this research topic. Working papers, reports and conference papers such as the Outsourcing Process and Theories from the POMS 18th Annual Conference held in Dallas (Perunović and Pedersen, 2007) and books like the Make vs. Buy revisited, reassessing your company’s manufacturing strategy by the A.T. Kearney consulting Agency, were not considered (Monahan, Van den Bossche and Tamayo, 2010). Previous literature review papers had also been exclusively based on the analysis of articles, leaving aside other sources, such as books or conferences (i.e. Gonzalez, Gasco and Llopis, 2006). Thus, a total of 99 articles –listed in Table 2-5 of Appendix 2-7– were finally analyzed.

2.3 Results

2.3.1 Period covered and journals analyzed

We analyzed 99 articles published during three decades, categorizing this period of time into three phases –shown in Figure 2-1– for the purpose of identify research trends over time. The
first stage of the analysis, focused on papers published before 1996, revealed that only 6 articles (6% of the reviewed papers) were published in this period. The second stage of analysis dealt with articles published between 1996 and 2006 (29 articles, or 29% of those reviewed), and the third stage comprises articles published after 2006 (64 articles, or 65% of the total).

Figure 2-1. Number of articles analyzed per period

![Figure 2-1](image)

Source: own source

One of the relevant articles, authored by McIvor (2013), highlights the convenience of using the Transaction Cost Economics and Resource-Based View (TCE-RBV) theories to understand the manufacturing location decision. This author illustrated complementary and contradictory prescriptions of both theories, his article belonging to the third and most relevant stage for this research work (i.e. articles published after 2006). Figure 2-1 illustrates a constant and steady growth in the publication of articles on make-or-buy decisions throughout the period under study. The preference for outsourcing may have influenced the outcomes of make-or-buy decisions too, the most outstanding aspect being the rising trend in the number of papers published after 2006.
Table 2-1. Number of papers per journal

<table>
<thead>
<tr>
<th>Journal</th>
<th>JCR Index 2016 (Q)</th>
<th>Area</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Journal of Operations and Production Management</td>
<td>3.339 (Q1)</td>
<td>Management</td>
<td>21 (21%)</td>
</tr>
<tr>
<td>Journal of Supply Chain Management</td>
<td>5.789 (Q1)</td>
<td>Management</td>
<td>18 (18%)</td>
</tr>
<tr>
<td>Strategic Management Journal</td>
<td>4.461 (Q1)</td>
<td>Management</td>
<td>18 (18%)</td>
</tr>
<tr>
<td>European Journal of Operational Research</td>
<td>3.297 (Q1)</td>
<td>Operations</td>
<td>15 (15%)</td>
</tr>
<tr>
<td>Journal of Operations Management</td>
<td>5.207 (Q1)</td>
<td>Operations</td>
<td>15 (15%)</td>
</tr>
<tr>
<td>Academy of Management Review</td>
<td>9.408 (Q1)</td>
<td>Management</td>
<td>12 (12%)</td>
</tr>
<tr>
<td>Journal of Purchasing and Supply Management</td>
<td>3.240 (Q1)</td>
<td>Management</td>
<td>5 (5%)</td>
</tr>
</tbody>
</table>

Source: own source

The findings of this thesis reveal a considerable number of articles published in journals, which combine the area of production with supply chain and strategic management (57 articles in all (21+18+18)). However, the relevance acquired by journals, which deal not only with purchasing but also with management review (15 articles), should be taken into account as well. Table 2-1 lists the number of papers analyzed per journal, the *International Journal of Operations and Production Management* (IJOPM) appearing as the most prolific journal in relation to the make-or-buy subject, with 21 articles published (21% of those reviewed).

IJOPM is closely followed by *Strategic Management Journal* and the *Journal of Supply Chain Management*, both of them with 18 articles published, after which can be found the *European Journal of Operational Research*, with 15 articles published, and the *Journal of Operations Management* with 12 articles. Finally, the *Academy of Management Review* and the *Journal of Purchasing and Supply Management* published 10 and 5 of the articles examined, respectively.

### 2.3.2 Research methods and relations

#### 2.3.2.1 Research methods

The papers were reviewed according to more than one dimension in this respect. After dividing them into empirical and non-empirical based on whether they applied some type of empirical method or not (Alavi, Carlson and Brooke, 1989), this thesis adopts the well-known empirical research categorizations (Van Horn, 1973) used in several research works with the
aim to understanding the methods followed in the literature. The distinction between empirical strategies stems from the definition formulated by Yin (2017).

More specifically, while field studies answer such research questions as ‘who,’ ‘what,’ ‘where,’ ‘how many’ and ‘how much,’ case studies exclusively focus on ‘how’ and ‘why,’ obtaining data through direct observation, interviews or document analysis, amongst other procedures. The problem with this basically qualitative data collection method lies in the difficulty to generalize the results, derived from the limited number of organizations under study.

Instead, field studies analyze several organizations by means of quantitative methods and collect data through surveys, their drawback being that the information loses depth and richness in comparison with case studies. (Gonzalez, Gasco and Llopis, 2006). This thesis follows the guidelines established by Seuring and Gold (2012) to identify articles which adopt a content analysis literature strategy. This is conducted by performing a descriptive assessment of the literature body according to specific analytical category patterns derived from a typical research process.

Table 2-2. Research methodology

<table>
<thead>
<tr>
<th>Research methodology</th>
<th>&lt;1996</th>
<th>1996-2006</th>
<th>&gt;2006</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field study</td>
<td>2</td>
<td>6</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>Multiple case study</td>
<td></td>
<td>10</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Field and case study</td>
<td>3</td>
<td></td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Single case study</td>
<td>3</td>
<td>2</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Content analysis</td>
<td>1</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Non-empirical</td>
<td>4</td>
<td>6</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>29</td>
<td>64</td>
<td>99</td>
</tr>
</tbody>
</table>

Source: own source

Table 2-2 illustrates the frequency with which the reviewed articles fell into empirical or non-empirical categories. 69% of the presented papers (or 68 articles) implemented an empirical research methodology, as opposed to 31% (or 31 articles) which showed a non-empirical approach. The studies undertaken by researchers until 1996 mostly had a non-empirical nature, the opposite trend becoming prevalent from then on. This thesis can consequently attest that the research methodology utilized by scholars changed from theoretical to empirical during the last decades. Scholars began to observe reality directly, instead of trying to speculate from outside adopting a purely theoretical perspective. This increase in the number of articles based on empirical research methodologies probably revealed, as suggested by
Brewer, Ashenbaum and Carter (2013), an attempt to validate theories which already existed. An example of this validation and extension can be found in the TCE-RBV combined theoretical framework proposed by McIvor (2009).

As for empirical studies, they can be classified into five groups according to their importance, namely: (1) field studies; (2) multiple case studies; (3) studies with a mixed case and field methodology; (4) single case studies; and (5) content analysis studies. Within the group of field studies –the most abundant ones (31 articles, 46% of empirical papers) – surveys stand out as the most popular research method. Researchers additionally collect information from uncontrolled situations, without influencing the responses of their study’s object. This method clearly seems to have prevailed over the rest after 2006. Similarly, Heide, Kumar and Wathne (2014) designed specific questionnaires to collect data from key informants as a way of validating their hypothesis by their concurrent sourcing research.

Articles based on multiple case studies (22 in all) were the next focus of attention. After a complete absence of articles based on this methodology in the first period under examination –before 1996– their relevance gradually increased during the following periods. Examples of such articles are provided by researchers such as Nordigarden et al. (2014) who applied a multiple case study methodology and drew conclusions from qualitative data collected through in-depth interviews with wood manufacturing firms. Furthermore, Perunović, Christoffersen and Mefford (2012) utilized a multiple-case study with 3 electronic manufacturers. Unlike single case studies, researchers are studying multiple cases to understand the differences and similarities between cases (Baxter and Jack, 2008).

Thirdly, articles based on the mixed field and case study methodology accounted for 12% (8 articles). Despite being more difficult to perform, such studies will enhance the overall understanding of make-or-buy approaches for both academics and practitioners. In this sense, Kistruck et al. (2015) successfully resorted to this methodology using a sample of 929 new foreign market initiatives and 60 interviews with initiative leaders, senior managers and country managers in the field, their purpose being to determine the relevance of client heterogeneity when it comes to predicting make-or-buy decisions.

The fourth group comprised 5 articles (5% of all those analyzed) characterized by the use of a single case study as their information collection method. It becomes evident that, although no articles followed this methodology during the first period, its use has been steadily increasing over time. A single case study appears as the best choice when researchers
want to study only one phenomenon (Yin, 2003). Similarly, Becker and Zirpoli (2003) adopted a case study methodology with the aim of integrating and coordinating specialist knowledge in the case of FIAT. Data sources such as interviews, documentation and observations are thus commonly used (Moses and Ahlström, 2009).

Finally, there were 2 articles based on a content analysis methodology (3% of all empirical articles). Priem and Butler (2001) tried to find out the extent to which the RBV can prove to be a useful perspective for strategic management research, whereas Gunasekaran and Ngai (2009) conducted a content analysis devoted to the supply chain literature. Table 2-5 in Appendix 2.7 specifies the method used in each one of the articles analyzed.

### 2.3.2.2 Relations

A subsequent categorization of research methods such as chain, firm, network or dyadic based on the research undertaken by Hooker et al. (2008)’s research –and developed from verifiable and tested evidence (Bacharach, 1989) – was employed. Table 2-3 shows the frequency the examined articles focus on (1) Chain; (2) Firm; (3) Network; or (4) Dyadic relations.

Articles about the supply chain as such formed the Chain category, while those written from a purchaser’s viewpoint fell into the Firm category. In turn, all the articles focused on factors associated with the make-or-buy network were labelled as belonging to the Network category.

Table 2-3. Relationships analyzed

<table>
<thead>
<tr>
<th>Level of analysis</th>
<th>&lt;1996</th>
<th>1996-2006</th>
<th>&gt;2006</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Empirical</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chain</td>
<td>2</td>
<td>23</td>
<td>43</td>
<td>68</td>
</tr>
<tr>
<td>Firm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td>1</td>
<td>8</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Dyadic</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td><strong>Non-empirical</strong></td>
<td>4</td>
<td>6</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td>Chain</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Network</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Dyadic</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6</td>
<td>29</td>
<td>64</td>
<td>99</td>
</tr>
</tbody>
</table>

Source: own source

Finally, the Dyadic category comprises all the articles centered on relationships between 2 parties. An examination of the data reveals that chain analysis stands out as the predominant category of analysis with a total of 32 empirical and non-empirical articles. The firm and the network category of analysis respectively accounted for 25% and 21% of all studies analyzed.
As for the number of published articles situated at the dyadic level of analysis, it grew significantly after 2006 (until reaching 21% of the total), the reason for this lying in the number of articles which examine the relationship between the buyer and its principal provider. An example can be found in the paper authored by Azadegan et al. (2008) who analyzed the extent to which principal provider performance impacts on buyer performance.

### 2.3.3 Subjects/topics

This section has as its aim to briefly highlight the most relevant subjects linked to the make-or-buy decision dealt with in the publications reviewed. A list of these topics appears in Table 2-4, which shows their presence by time periods together with the number of topics addressed by each article. The categorization of the reviewed articles –based on the main topic examined in each article (relegating secondary topics outside the statistic) and adapted from Hooker et al. (2008) – resulted in 12 categories which are displayed in Table 2-4.

These are the 12 categories used in this study: (1) Outsourcing; (2) Risks; (3) Strategy; (4) Performance; (5) Relationships; (6) Theories/Concepts; (7) Plural sourcing; (8) Bargaining power; (9) Make-or-Buy analysis; (10) Resources / Capabilities; (11) Supply Chain Management; and (12) Other unclassifiable topics of minor relevance. The categories analyzed may fall upon several thematic areas and be combined with others in different papers. The topic dealt with in all the articles examined can be found in Appendix 2-7.

#### Table 2-4. Subject category per period

<table>
<thead>
<tr>
<th>Subject</th>
<th>&lt;1996</th>
<th>1996-2006</th>
<th>&gt;2006</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsourcing</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Risks</td>
<td>7</td>
<td>5</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Strategy</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Performance</td>
<td>2</td>
<td>8</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Relationships</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Theories</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Plural sourcing</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Bargaining power</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Make-or-Buy analysis</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Resources / Capabilities</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Supply Chain Management</td>
<td></td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
<td><strong>29</strong></td>
<td><strong>64</strong></td>
<td><strong>99</strong></td>
</tr>
</tbody>
</table>

Source: own source

The most commonly discussed topic is **Outsourcing** (15 papers), as can be seen in the paper authored by Laios and Moschuris (1999) which focuses on outsourcing decisions from an
empirical point of view. Another approach to outsourcing comes from Marshall et al. (2015), who studied the influence of political and rational dynamics on this phenomenon. The second most important topic is Risks – represented with 12 articles. Outstandingly, Zsidisin (2003) analyzed managerial perceptions about supply risk, Handley and Benton Jr. (2012a) investigating the influence of exchange hazards and power on opportunism in the context of outsourcing relationships. Based on a strategic outsourcing model (Hitt and Holcomb, 2007), professionals can more accurately assess the impact of outsourcing on supply chain and firm performance (Park and Ro, 2011), considering possible hazards by means of a suitable, ad hoc risk assessment tool.

The topics ranking third, fourth, fifth and sixth in order of importance are Strategy, Performance, Relationships, and Theories – all four of them treated by 10 articles (9%) and connected with one another. Decision makers face the challenge of finding the strategy which best suited not only to achieving their organization’s goal with the least possible risk, but also to ensuring its best and most profitable performance. Strategy arises as the key factor determining a firm’s vision and mission. By way of example, Boulaksil and Fransoo (2010) investigated the strategic implications of outsourcing on operations planning through a case study about the pharmaceutical industry.

The topic Performance has strategic relevance for researchers, insofar as firms require a mechanism to measure the profitability derived from their make-or-buy decisions. In particular, Park and Ro (2011) studied the impact of a firm’s ‘make,’ ‘pseudo-make,’ or ‘buy’ strategy on product performance. Key performance indicators should be defined and used by practitioners for them to continuously measure ‘make-and-buy’ performance on a permanent basis.

The topic Relationships specifically focuses on outsourcing relationships between principals and external providers. Many of these articles support the relationship theories formulated by Klepper (1995) and Kern (1997). Whereas Mohr and Spekman (1994) explored the topic of relationships based on a field study, Boulaksil and Fransoo (2010) selected a multiple case study strategy. Experts should become aware of intercultural differences prior to choosing their make-or-buy approaches (Handley and Angst, 2015). A better identification of the main attributes determining partnership success would enhance the position of professionals when it comes to selecting, managing and developing an external provider (Mohr and Spekman, 1994). ‘Characteristics of partnership success’ stands out as one of the relevant categories mentioned by scholars supporting mainly social exchange theories, agency
theories and cooperation strategies. Both lack of trust and lack of regular communication between both parties can negatively influence outsourcing relationships.

The category *Theories/Concepts* allowed us to bring together those articles which deal with conceptual papers. Categorized under this topic are the papers by Eisenhardt (1989), who sought to assess and review the agency theory, and the one written by Balakrishnan and Cheng (2005) which served to analyze and update the theory of constraints employed at the make-or-buy process. In addition to this, Eisenhardt (1989) highlighted the firm’s concept as a nexus of contracts between principals and agents which can afford protection against opportunist threats. A prior evaluation of chances and risks should help decision makers avoid wrong approaches. Potential risks, outcome uncertainties and possible incentive-mechanisms should be considered and assessed too.

Once the evaluation has been conducted, firms will be able to identify the most optimal contract for a particular case: outcome-based or behavior-based. Contracts should be designed as a monitoring instrument and an incentive-creating mechanism (Eisenhardt, 1989; Jensen and Meckling, 1976). For instance, firms choose and adopt both (1) incentives and (2) penalty plans, such as (1) 5% of purchased quantity as a bonus to principals for reaching an agreed sales target or (2) reducing the purchasing volume and charging extra costs to agents following a poor delivery or an inadequate quality performance. Such incentives and penalty methods should also form an integral part of the internal procedures applied within a firm or a firm group (vertical integration).

The seventh position in this ranking corresponds to 6 articles revolving around the topic of *Plural sourcing* which study how firms can make-and-buy at the same time. Traditionally, scholars investigated the make-or-buy decision on a dichotomous basis completely ignoring the concurrent sourcing approach (Parmigiani, 2007). A proper balance between vertical integration and strategic outsourcing will most probably have an influence on product portfolio, product success, and firm performance (Rothaermel, Hitt and Jobe, 2006); hence why performance outcomes associated with the choice of governance mechanisms should be assessed as well (Heide, Kumar and Wathne, 2014).

Despite the high number of articles which refer to outsourcing in general, a total of 6 articles focus on *Bargaining power* in the relations between principals and external providers — single source or multiple source strategy? Obviously, a single source strategy increases the firm’s dependence on its external provider and reduces its negotiation capacity. Being really
able to maintain a credible threat to change external providers will endow firms with more bargaining power when it comes to negotiating better conditions and obtaining cost reductions from their providers (Aláez-Aller and Longás-García, 2009).

This privileged position may be restricted by previous contractual commitments, as a result of which changes in bargaining power can lead to governance inseparability (Argyres and Liebeskind, 1999). Furthermore, shifts in bargaining power are associated with the acquisition of sufficient knowledge and skills to eliminate dependence on one partner, especially in joint ventures (Inkpen and Beamish, 2007).

Five articles directly address the Make-or-Buy analysis as the main topic. Having to choose between manufacturing a product in-house or purchasing it from an external provider represents a central dilemma faced by many experts. It becomes crucial to resolve this dilemma in a structured manner and using the most appropriate tools (Cánez, Platts and Probert, 2000). Setting in motion the right mechanisms (Moschuris, 2007) and taking advantage of the most relevant drivers will give decision-makers better insights to successfully address that make-or-buy dilemma (McNally and Griffin, 2004).

Resources / Capabilities stands out for being another popular topic, as shown by the five published articles belonging to this category. Resources are assets owned by an organization which can be physical, tangible, and human. In turn, capabilities are complex patterns related to skills when utilizing resources to achieve a desired product or service. Resources and capabilities are essential for an organization’s competitive advantage. Articles within this domain have focused on arguing that capabilities serve as shift parameters from insourcing to outsourcing (Jain and Thietart, 2013) – and vice versa – when firms own better capabilities than their potential external providers (Argyres, 1996). Added to this, Peeters and Martin (2015) drew a distinction between the use of external knowledge for replication purposes (using knowledge itself) and the one which focuses on compounding (building on acquired knowledge by combining it with internally developed knowledge).

The articles based on Supply Chain Management accounted for 5% of the total (5 articles). The problem faced by professionals consists in identifying which supply chain strategy best adapts to their firms’ goals. According to some researchers, the need for flexibility constitutes a key criterion for firms to rapidly meet their customers’ demands. Firms may improve flexibility throughout the chain by engaging in committed relationships with external providers (Stevenson and Spring, 2009). On the other hand, Atkins and Liang
(2010) suggested that decentralization can be preferable for competitive supply chains because it increases the unit supply cost of direct competitors.

Finally, five articles dealt with Other issues, amongst them the one written by Leiblein and Miller (2003) which examines transaction-and firm-level influences along the vertical boundaries of the firm.

2.3.4 Theoretical framework

Input from sections 2.3.1 and 2.3.2 was collected below seeking to build a comprehensive conceptual make-or-buy framework able to capture relevant determinants and theories which need to be taken into account in such decisions. Such a framework developed in accordance with the guidelines proposed by Miles and Huberman (1984) and its subsequent implementation by Cánez, Platts and Probert (2000). Furthermore, as the extant literature review confirms a need for developing a new conceptual framework which illustrates the importance and results of the theories and determinants identified on the examined articles. For instance, possible outcomes identified from the literature review are summarized in this study.

2.3.4.1 Theories utilized in the articles examined

The articles under review were classified following the categorization in the Theoretical Foundations theory proposed by Dibbern et al. (2004), who defined the Theoretical Foundations for outsourcing research in nine theories which are listed with the research analytical results in Figure 2-2. The analysis determines whether the research supports (1) Resource theories; (2) Transaction Cost Economics (TCE); (3) Strategic Management theories; (4) Relationship theories; (5) Agency theory; (6) Social Exchange theory; (7) Game theory; (8) Innovation theories; (9) Power and Politics theories; or a combination of several of those theories. Each paper’s categorization takes into account which theories are most relevant for it. Additionally, this thesis has identified researchers supporting several theories in the same article.
Figure 2.2. Theoretical framework

Source: own source

(1) *Resource Theories* search for a competitive advantage; according to the RBV, the option ‘make’ prevails whenever the firm’s resource position is high, the option ‘buy’ predominating in the opposite case.

(2) *TCE*, which plays a fundamental role in the make-or-buy decision, claims that the option ‘make’ should be taken if the potential for opportunism is high – the option ‘buy’ being preferable with a low potential for opportunism.

(3) From a *Strategic Management Theories* point of view, the adopted make-or-buy choice consists in the initiatives and the allocation of the resources needed to achieve the firm’s long-term goals. A trend observed in the articles examined is the combination of several theories to resolve the make-or-buy dilemma. This option mainly received support from McIvor (2009), according to whom neither TCE nor RBV alone can explain and address the make-or-buy decision. Nearly half of the papers analyzed are structured around *RBV, TCE* and *Strategic management theories* to some extent, and partially support a combination of these three theories (54% (19%+18%+17%)).

Whereas RBV theory sees the relative capability of focal firms and exchange partners as an important factor for ‘make’ decisions, transaction-based perspectives explain different
governance forms (Argyres, 1996; Hitt and Holcomb, 2007). In turn, strategic theories focus on firms’ strategic advantages and long-term plans to improve their operational performance. The integration of TCE, RBV and relevant concepts such as performance management or operations strategy have been highlighted by renowned researchers –most importantly, McIvor (2009) – and not only validated but also enlarged with performance attributes by Brewer, Ashenbaum and Carter (2013). Even though the framework proposed by McIvor (2009) contains contradictory prescriptions stemming from RBV and TCE when it comes to outsourcing decisions, the integration of TCE and RBV theories is supported by a broad representation of the research community.

(4) The second most strongly supported –and recently favored– theory within the make-or-buy field after the combination of the aforementioned theories is the ‘relationship theory,’ which accounted for 13% of the reviewed papers. Relationship theories focus on the interactions between parties such as principals and agents which are adapted so that those parties can accomplish their individual objectives and reach successful partnerships. Relationship theories work between firms and exchange partners, as well as within the firm itself. While being compensated for choosing external providers based on price only leads to a decreasing joint action, McNally and Griffin (2004) suggest that being compensated for implementing close relationships leads to an increasing joint action.

Several notable trends were identified concerning the importance of using appropriate communication –particularly in terms of frequency, quality and mode– between firms. Parker and Russell (2004) suggested that a decrease in cooperation, trust, approachability, communication, fairness, helpfulness and poor communication between firms causes confusion, frustration, and annoyance, which is likely to result in a low performance of external providers. Collaboration and interdependence appear as essential ingredients in the management of supply chain performance that require establishing long-term cooperative relationships (Howard and Squire, 2007) with preferred external providers (Cox et al., 2005).

(5) The next most relevant topic –present in 9% of the papers– is the agency theory, which helps expose problems of divergent interests in outsourcing and suggests the convenience of ensuring an optimal contractual relationship between principals and agents to reduce the degree of uncertainty usually inherent to agents’ behavior. The agency theory reminds us that much of organizational life is based on incentives and self-interest (Eisenhardt, 1989), and outsourcing does not seem to be the most advisable choice when the
output cannot be measured, an insufficient quality level exists, cost uncertainty is high, and agents show a hostile attitude (Balakrishnan, Mohan and Seshadri, 2008).

(6) As for Social exchange theories, they support the reciprocity of benefits and costs through an exchange of activities between both parties (Emerson, 1972). This theory holds true for internal as well as for external exchanges. The principle underpinning the social exchange theory is the assumption of exchange reciprocity in terms of benefits and costs; 9% of the papers partially support this approach. It additionally deserves to be highlighted that this theory has proved to combine with the game theory in some research works.

(7) The game theory starts from the premise that every player under the same conditions makes rational and intelligent decisions seeking to maximize their respective profit (Fudenberg and Tirole, 1990; Dibbern et al., 2004). Thus, firms facing the fear of imitation could and should reduce the use of external sources (Giarratana and Mariani, 2014). As said above, the option of using the game theory in combination with the agency theory is backed by a number of researchers, support for the game theory accounting for 6% of all the articles under review. Proper relational contracts become of paramount importance to improve supply chain collaboration, ultimately seeking to safeguard firms’ interests and to prevent opportunistic behaviors on the part of future external providers. Informally promising future interactions to sustain collaboration sounds more feasible to external providers than to internal units, insofar as the provider can use its assets elsewhere (Brahm and Tarziján, 2016a).

(8) Finally, innovation theories, together with power and politics theories respectively accounted for 6% and 2% of all the articles examined. Innovation theories see the make-or-buy decision as a way to adopt innovations and new technologies, spreading them throughout firms (Rogers, 1983). For instance, firms might be choosing to source out the development of a product due to the lack of in-house skills.

The previous question about the extent to which firms’ decisions to outsource or internalize R&D, production or specific processes or services affect their technological performance is one that experts often ask themselves.

Interestingly, Leiblein, Reuer and Dalsace (2002) posed that a firm’s technological performance is contingent upon the alignment between firms’ governance decisions and the significance of contractual hazards. Outsourcing has been aligned to reduce costs and improve flexibility. Firms can enhance their innovation performance in the near future by gaining access to external providers’ knowledge. However, a combination of knowledge with external providers might spill over the firm’s own internal knowledge, especially in regions populated
by organizations with a high absorptive capacity (Giarratana and Mariani, 2014). A ‘make’
decision will be preferred in such cases.

(9) *Power and Politics* theories claim that government regulations and political
instability are likely to determine the viability of a firm’s strategy, accordingly having an
impact on make-or-buy decisions too. Indeed, power and politics can play an important role
when it comes to make-or-buy decisions (Lacity and Hirschheim, 1993b), as shown by the
fact that some very powerful firms and individuals even find themselves in a position to
strongly influence regulations, politics and markets (Harland, Brenchley and Walker, 2003).
Firms may not have the capability to eliminate or mitigate many of the external political and
regulatory risks, though.

### 2.3.4.2 Determinants for make-or-buy decisions

Our classification of the articles under review was based on the definition of determinants for
outsourcing proposed by Dibbern et al. (2004), the most representative determinants
identified through the articles examined in the present paper being: (1) Costs; (2) Strategy; (3)
Capabilities; (4) Uncertainty; (5) Monitoring; (6) External forces; (7) Information; and the
combination of several of those determinants. The categorization of each paper takes into
account which determinants are more relevant for it. Thus, this thesis identifies researchers
proposing several determinants for the make-or-buy decision in the same article.

(1) *Costs* include both the organization’s relative performance efficiency and its
transaction, agency and hidden costs. *Cost* reduction arises as the main driver for outsourcing
—it accounts for 64 articles (22% of all the articles analyzed). This result matches those
obtained by researchers such as Moschuris (2007), who suggested that cost saving constitutes
the most important criterion when exploring make-or-buy decisions.

(2) *Strategy* comprises strategic significance analysis, strategic importance and fuzzy
focus. The second most important factor for make-or-buy decisions is the *strategy* adopted by
the firm itself (it is present in 21% of the papers). Firms may outsource non-core activities
with the aim of focusing on core activities in-house, if the latter are defined as strategic and
non-transferable for the firm (Miles and Snow, 1978).

(3) 19% of the articles examined present *capabilities* as an important factor to address
the make-or-buy dilemma. *Capabilities* embrace gaps in manufacturing capabilities, leverage
internal technical capabilities, along with internal and vendor capabilities. The resource
position of a firm can determine whether a product or service should be sourced in or out.
Moreover, Quinn and Hilmer (1994) stated that the loss of critical internal skills can be avoided through a structured insourcing or outsourcing management.

(4) **Uncertainty**, with a proportion of 15% of the total includes a variety of root sources, amongst which stand out sales, market or product uncertainty. **Uncertainty** involves endemic uncertainty, unexpected and undesirable outcomes too.

(5) **Monitoring** contains both the inability to control external providers and the loss of control over external providers (. **Monitoring** and **external forces** accounted for 8% of the papers under analysis. Albeit possibly having little relevance for domestic outsourcing, **Monitoring**, auditing, surveillance and supporting costs can become much higher for offshore outsourcing. **Monitoring** costs should be taken into account prior to addressing the make-or-buy decision.

(6) As for **External forces**, they refer to those factors likely to affect the make-or-buy process which have to do with market prices for raw material supplies. These forces are additionally related to consumer demand for firms’ finished products, government regulations, and the strength of effective competition. **External forces** such as political instability, national or international regulations, or even natural catastrophes influence the manufacturing location decision. Firms can pursue a vertical integration strategy, incorporating additional plants into their business group or seeking partnerships and alliances with third parties that will allow them to enter new markets.

(7) Finally, **information** –the relevance of which amounts to 7%— plays a significant role in firms’ relationships. **Information** covers the dependence on information and the importance of having sustained innovative information available. Sustained innovation comes from sharing information with external providers on a regular basis. Bidirectional communication and mutual information sharing help avoid the emergence of asymmetric information between firms and their external providers. Asymmetric information, sometimes referred to as information failure, arises whenever one party possesses greater product or service knowledge than the other during an exchange process.
2.4 Discussion

2.4.1 Theoretical and managerial implications of the chapter’s findings

What should a small and medium-sized enterprise (SME) or a large enterprise know when they face make-or-buy decisions? After performing an in-depth analysis of the articles under examination, the following trends stood out:

(1) Combination of multiple theories: the make-or-buy decision can neither be explained nor resolved by one theory alone; a combination of multiple theories is needed which can complement each individual theory, contradicting deficits of addressing make-or-buy decisions based on only one theory. More than half of the papers analyzed support the combination of several theories to address the make-or-buy approach in some way or another. Whereas the RBV theory assigns importance to the relative capabilities of focal firms and exchange partners in ‘make’ decisions, the TCE theory explains different governance forms, and strategic theories focus on firms’ strategic advantages and long-term plans to improve their operational performance. The combination of those theories should be taken with caution in the light of some contradictions. The challenge for researchers lies in finding a correct balance between such theories in order to adapt them to address certain make-or-buy decisions. A conceptual framework was developed to help professionals evaluate sourcing decisions. Unlike the results obtained by McIvor (2009), ours suggest not only considering the TCE and RBV theories to evaluate manufacturing location decisions but also take account of additional theories such as strategic and relationship theories.

(2) Risk mindset: the relevance according to the number of articles which discuss the possible hazards and threats of outsourcing makes it advisable to prioritize this topic and taking it into account. Practitioners and managers can more accurately assess the impact of outsourcing on supply chain and firm performance through a suitable risk assessment tool. The possible risks and chances involved in dealing with make-or-buy issues should be evaluated during the make-or-buy process, as required by the ISO 9001:2015 revision. The results are in keeping with the evaluation of the potential for opportunism risks, implemented within the framework developed by McIvor (2009). The findings of the thesis suggest that firms should evaluate emergency plans, analyzing second source options in order to minimize risks.
(3) **Relationship success factors:** the importance of relationships and the characteristics of partnership success have been widely discussed by researchers who mainly support social exchange theories, agency theories and cooperation relationships. The categorization of the articles under review was structured around the factors described by Lehtonen (2004), listing the supported success factors on a spreadsheet so that the factors most commonly supported in the literature examined could be validated.

This spreadsheet contained the attributes and success factors identified in the articles under review. Those attributes and success factors are summarized in Figure 2-3. An identification of the most important partnership success characteristics would place practitioners in a better position to select, manage and develop external providers. Decision makers should be aware of intercultural communication techniques prior to addressing a make-or-buy approach. Which factors make a partnership successful?

Out of 99 papers analyzed, 36 partly mentioned one or several success factors or attributes, which were clustered following the factors proposed by Lehtonen (2004). It follows from the identified articles that the most frequent success factors of partnership are the relationships based on collaboration and the willingness to adopt a joint problem-solving strategy (97%), headed by the next significant ones being bidirectional clear and open information sharing with 58%. This result follows along the lines of collaboration with supplier factor implemented at the framework developed by Cánez, Platts and Probert (2000). Clearly defined and mutually agreed goals, incentives and penalties accounted for 42% (or 15 papers). Regularly updating costs and information, and mutual involvement in the development of the partnership accounted for 31% and 25% respectively.

Finally, a mutually agreed long-term perspective and the ability to meet agreements in time and properly respectively represent 11% and 8% of the total (36). What are the attributes of partnership relationships? The attributes of partnership relations most commonly supported in the examined articles mainly revolved around such aspects as: communication quality and participation (78%), mutual trust (67%), commitment (39%), sharing opportunities and risks (17%), homogeneity (17%), intercultural understanding (14%), continuous improvement (8%), fairness (6%), honesty (6%) and involvement and support on all firm levels (3%). Looking for partners and external providers with such attributes can positively influence future outsourcing relations.

Firms’ achievements in the area of sustainable development are currently evaluated using the data provided by their Company Social Responsibility (CSR) report. Firms showing
the best CSR reputation are the ones which ensure their active compliance with the spirit of the law, ethical standards and national and international norms. Experts and practitioners should evaluate which type of relationship best suits each external provider selected.

Figure 2-3. Characteristics of partnership success

<table>
<thead>
<tr>
<th>Factors</th>
<th>% (N)</th>
<th>Attributes</th>
<th>% (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The will to collaborate and joint problem-solving</td>
<td>97% 35</td>
<td>Communication quality and participation</td>
<td>78% 28</td>
</tr>
<tr>
<td>Bidirectional clear and open information sharing</td>
<td>96% 24</td>
<td>Mutual trust</td>
<td>67% 24</td>
</tr>
<tr>
<td>Clearly defined and mutually agreed goals, incentives and penalties</td>
<td>42% 15</td>
<td>Commitment</td>
<td>39% 14</td>
</tr>
<tr>
<td>Regularly updating cost and information</td>
<td>58% 15</td>
<td>Sharing chances and risks</td>
<td>17%  6</td>
</tr>
<tr>
<td>Mutual involvement in development the partnership</td>
<td>6%  9</td>
<td>Homogeneity</td>
<td>17%  6</td>
</tr>
<tr>
<td>Mutually agreed long-term perspective</td>
<td>11%  4</td>
<td>Intercultural understanding</td>
<td>14%  5</td>
</tr>
<tr>
<td>Ability to meet agreements in time and in an appropriate way</td>
<td>8%  3</td>
<td>Continuous improvement</td>
<td>8%  3</td>
</tr>
<tr>
<td>Source: adapted from Lehtonen (2004).</td>
<td></td>
<td>Fairness</td>
<td>6%  2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Honesty</td>
<td>6%  2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Involvement and support on all firm levels</td>
<td>6%  2</td>
</tr>
</tbody>
</table>

(4) *Plural sourcing and Hybrid sourcing*: in addition to the dichotomous make-or-buy approach, the research identifies an increase in the number of papers supporting the plural sourcing option literature after 2007. Hence, the articles analyzed are categorized on a spreadsheet concerning the articles addressing Plural and Hybrid sourcing. This analysis showed that researchers use a wide range of terms when referring to this topic. Examples are (1a) concurrent sourcing; (1b) plural sourcing; or (1c) parallel production; (2a) mixed sourcing; (2b); pseudo-make; or (2c) hybrid sourcing.

Unlike Heide, Kumar and Wathne (2014), who argued that concurrent sourcing in itself suppresses external provider opportunism, Nordigarden et al. (2014) presented a variety of scenarios to solve production planning needs through the assessment of the ‘make,’ the ‘buy’ or a combination of both. In turn, Puranam, Gulati and Bhattacharya (2013) proposed an integrated framework to explain how complementarities and constraints encourage plural sourcing and identify the optimal mix of internal and external sourcing. Cassiman and Veugelers (1997) likewise confirmed the complementary nature of make-and-buy decisions as an evidence from Belgian manufacturing firms.

Internal and external sourcing can prove synergistic when used concurrently. Plural sourcing refers to the splitting up of the total volume procured by means of multiple modes, each of which may be a pure governance mode. Plural sourcing uses two mechanisms
simultaneously. Instead, hybrid sourcing refers to the procurement of the entire volume from a single mode that exhibits mixed governance characteristics. Hybrid sourcing represents a procurement mode characterized by a degree of cooperation and coordination which is unusual in market relationships. As opposed to the Make-or-Buy controlling matrix proposed by Brem and Elsner (2018), the results suggest that not only the pure make or buy strategy should be assessed, plural and hybrid sourcings need to be considered as well.

(5) Structured, documented process and skilled personnel: the thesis follows the same procedure as in Section (3). The articles analyzed were categorized with regard to the ones that resolved the make-or-buy process in a systematic and structured way and subsequently listed on a spreadsheet. By way of example, Moses and Ahlström (2009) as well as Baines et al. (2005) were in favor of addressing make-or-buy decisions in a structured manner, and Cánez, Platts and Probert (2000) proposed a framework to fill this gap in the literature. Another managerial implication is the consideration of product/subsystem aggregation schemes and make-or-buy controlling matrices to operationalize the make-or-buy framework, as pointed by Brem and Elsner (2018). They posited that complexity costs can be reduced by simplifying the decision-making level. This is in keeping with the preference for addressing the make-or-buy in a structured manner after the results obtained. It can be inferred from the articles under analysis that, if the approach during the make-or-buy decision process is neither structured nor standardized, manufacturing organizations are likely to lose competitiveness.

A wrong decision can influence the organization’s future. The make-or-buy decision process should be structured, documented and conducted by a multi-disciplinary team. The staff involved in this process should be qualified and receive training periodically. Firms will require outsourcing experts and skilled personnel with experience in outsourcing relationships; which is why they should put in place processes to ensure the transfer of this know-how to new employees.

(6) Stages in the make-or-buy decision process: the literature review made it possible for us to categorize the stages in the make-or-buy processes mostly following the models proposed by Baines et al. (2005), Cánez, Platts and Probert (2000) and the process methodology standardized by the ISO 9001-2015 PDCA-Cycle (ISO, 2015). In contrast to their results, this research suggests that practitioners should take the improvement stage into consideration for possible re-evaluations. The information obtained from the articles examined with regard to addressed make-or-buy stages was listed on a spreadsheet.
Additionally, the research identifies that the terminology used by researchers varies to a large extent, which stresses the need to standardize all these terms in accordance with the ISO 9001 norm.

The complete decision process is described as having 4 stages: (1) planning; (2) data collection and analysis; (3) performance evaluation; and (4) improvement. The project leader assigned for the make-or-buy decision, plans, coordinates and leads activities making sure that tasks are accomplished according to the milestones plan. Achieving the key milestone dates on time turns out to be essential for the multidisciplinary team involved in the process.

The overview is graphically represented in Figure 2-4. Any organization making a make-or-buy decision should critically examine and carefully explain what they want to achieve through insourcing or outsourcing. The planning phase establishes the objectives sought with the make-or-buy process and the resources required (including the selection of a multidisciplinary team) in accordance with the firm’s strategy, additionally identifying and addressing both risks and opportunities. The data collection and analysis can be divided into three subcategories: (a) attribute generation; (b) attribute weighting; and (c) attribute rating. The highest score of the decision matrix indicates the best option in the analysis.

Determinants for outsourcing such as costs or capabilities –included within the criteria defined by Baines et al. (2005) – can be taken into account as a reference for attribute generation. During the performance evaluation, the research estimates the results of possible actions resulting from the previous stage, performing a SWOT analysis and preparing a proposed action plan ranked in order of potential effectiveness. The improvement stage has as its aim to undertake proposed actions by allocating both a timescale and responsibilities, and to verify the firm’s strategic position and, if necessary, improving it from the lessons learned.
Automation as a complementary or substitute for offshore outsourcing: a number of certain risks linked with offshore outsourcing, amongst which stand out product recalls, long delivery times and complex relationships with external providers, make it advisable to consider the automation option. Experts deciding to outsource in offshore locations should be particularly aware of the fact that such a strategy entails risks and therefore they should adopt the necessary preventive actions.

Two main alternatives are available to professionals: either (1) outsourcing locally where firms can have a higher degree of control and a better relationship with the external provider (Steven, Dong and Corsi, 2014) or (2) insourcing the product or service through the development of an automated manufacturing process or a smart factory. The automation trend known as industry 4.0 creates what has come to be known as ‘smart factories’ –where firms can perform automated processes, reduce production costs, and improve quality failure rates. The search for automation is expected to grow, which means that the threat of automation will continue to increase. Opportunities exist for firms able to combine their services with a certain level that will give them more governance over the process. This ‘ownership of the
process’ factor is also addressed in the framework designed by Cánez, Platts and Probert (2000). They did not consider the smart factory insight, though.

(8) Main determinants for the make-or-buy process: the articles examined tend to show a prevalence of the factor cost as the major determinant for insourcing or outsourcing. This trend was empirically confirmed in the hotel sector by Espino-Rodríguez and Rodríguez Díaz (2017). Nevertheless, firms which still make their sourcing decisions based only on cost will eventually die (Welch and Nayak, 1992).

Cost, strategy and capabilities appear to be the most significant criteria, which suggests that firms usually resolve tactical make-or-buy issues seeking to achieve cost savings and strategic or operational advantages. The results are in keeping with the framework of Brem and Elsner, 2018, where the relevance of a firm’s strategy ensure the identification of its core competencies. Uncertainty, external forces and monitoring play an important role for the outcomes of make-or-buy decisions. Finally, information deficits together with information asymmetry add to the administrative demands of organizing transactions and impact negatively on supply chain sourcing.

2.4.2 Limitations and further research

Notwithstanding the above findings and contributions, this study faces a number of limitations and so do its outcomes. Firstly, a potential limitation of this study stems from the fact that the in-depth analysis focused exclusively on articles published in 7 prestigious journals. Secondy, using only the ProQuest, Scopus and Web of Science databases in the present study may have prevented us from covering all the articles in the field of ‘make-or-buy.’ Furthermore, this review is limited to research published in articles, leaving aside other sources such as books or conference reports. This limitation concerning the selection of sources analyzed can hardly be avoided in any literature review. However, the findings seem to provide a valuable understanding of the current situation in this research field. The present study equally suggests a number of future research strands which may encourage more intensive research in this important area.

This research can prove useful for both researchers and decision makers, since both areas reflect new trends that will probably lead to future research and future implementation inside firms. Hopefully, the present paper will trigger a new approach to studying make-or-buy decisions, to which must be added that the outlined results provide practical guidelines to
adopt a sourcing strategy based on the relevance that corresponds to the various determinants for the firm.

There is clearly still plenty of room for growth and improvement within the make-or-buy literature. For instance, the academic literature has multiple studies focusing only on one link addressing the make-or-buy (focal firm to principals or focal firm to agents). A chance for future researchers also stems from the empirical validation of the proposed theoretical framework.

Basically, does the make-or-buy process require a make-or-buy specialist within firms? Does such a position exist? Has a training program been put in place? How is this knowledge transferred to the next generation? Aspects such as the proximity to markets, the macroeconomic and political situation, trade implications, profitability, technical differentiation, contract manufacturers’ capability, along with core or non-core activities strongly influence this decision.

Admittedly, the research questions listed below have already been investigated. Nevertheless, the findings of this thesis prove that a need exists to continue updating the dichotomous make-or-buy decision so that the scientific community can be helped with updated and new research insights. What considerations are borne in mind during the make-and-buy’s decision process? To what extent does the make-and-buy impact on firms’ operational performance? Why are fixed and hidden costs ignored in make-and-buy decisions? How can organizations implement these structured decision-making models? As far as the make-and-buy is concerned, it does not suffice to consider the aforementioned theoretical models or explanations for the outsourcing phenomenon, practitioners must do things differently the next time in order to avoid past failures in the future.

### 2.5 Conclusion

The research presented in this paper has important implications for theory and practice both regarding the supply chain as a whole and more precisely in terms of procurement management. Despite undoubtedly providing valuable results, the literature review carried out so far were based on a random selection of articles focused mainly on the TCE theory. This paper aims to analyze the determinants for the make-or-buy decision in supply chain management through the analysis of 7 prestigious academic journals. The most outstanding aspect identified is the upward trend in the number of papers published from 2006 onwards.
The growing popularity of outsourcing may also have some bearing on the outcomes of make-or-buy decisions. The articles assessed followed a variety of research methods, favoring empirical techniques to a greater extent than those of a purely theoretical nature. Within the empirical methods, the field study has been used more profusely for designing surveys for purchasers and decision makers involved in make-or-buy decisions.

A description is made about the theoretical framework for make-or-buy evaluation, its development being structured around the integration of the most widely supported theories and determinants in the literature under review. The results seem to confirm the link between those theories and insights: (1) TCE; (2) resource theories; (3) strategic theories and the most relevant determinants; (1) costs; (2) capabilities; (3) strategy to address make-or-buy decisions. The findings emphasize the importance of evaluating not only traditional pure sourcing – ‘make or buy’ – but also the combination of both ‘make-and-buy’ (plural sourcing), ‘hybrid sourcing’ and strategic alliances so that firms can design the manufacturing strategy which best fits their structure.

The make-or-buy assessment framework presented intends to deal with the trends identified in the literature by capturing relevant approaches considered in make-or-buy decisions. It has as its aim to provide a graphical representation of relevant dimensions which need to be studied when examining make-or-buy decisions. One of the main contributions made by the article consists in the preparation of a list with the trends identified in the literature together with the categorization of the most outstanding subjects found in the specific articles examined. An analysis of these trends should help clarify the topics which raise the most interest amongst researchers.

The findings of the thesis also highlight the importance of addressing make-or-buy decisions in a structured manner. A multi-disciplinary team should evaluate the possible risks and chances involved in dealing with make-or-buy issues through a suitable and adapted risk assessment tool. A four-stage model for the decision process which follows the trend observed in the literature reviewed has been suggested and adapted to the PDCA-Cycle (Plan, Do, Check, Act) according to the requirements of the ISO 9001:2015 norm.

Therefore, in a common manufacturing situation where multiple principals are depending on external providers and where hazardous behavior cannot be punished, it is perhaps better to rely on building up a “win-to-win” relationship regulated by “external provider agreements” with defined contracts that can influence multiple sources and long-term-relationships. Moreover, it becomes clear that cost reduction alone is not the most
decisive factor for make-or-buy; aspects such as the risk of core capabilities, strategy, uncertainty, flexibility, capital requirements, financial returns, and level of skills and expertise need to be considered as well.

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Realities, Chichester, New York: Wiley.


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### 2.7 Appendix

Table 2-5. Papers analyzed: research methodology, subject category and theory utilized

<table>
<thead>
<tr>
<th>Paper</th>
<th>Research Methodology</th>
<th>Subject category</th>
<th>Theory employed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry, Schmitt and Vollmann (1982)</td>
<td>Field study</td>
<td>Resources / Capabilities</td>
<td>Resources</td>
</tr>
<tr>
<td>Chakravarthy (1984)</td>
<td>Theoretical</td>
<td>Strategy</td>
<td>Strategic</td>
</tr>
<tr>
<td>Harrigan (1985)</td>
<td>Theoretical</td>
<td>Bargaining power</td>
<td>Strategic</td>
</tr>
<tr>
<td>Eisenhardt (1989)</td>
<td>Theoretical</td>
<td>Theories</td>
<td>Agency</td>
</tr>
<tr>
<td>Yoon and Naadimuthu (1994)</td>
<td>Theoretical</td>
<td>Make-or-Buy analysis</td>
<td>-</td>
</tr>
<tr>
<td>Mohr and Spekman (1994)</td>
<td>Field study</td>
<td>Relationships</td>
<td>Relationship</td>
</tr>
<tr>
<td>Argyres (1996)</td>
<td>Multiple case study</td>
<td>Resources / Capabilities</td>
<td>Resources</td>
</tr>
<tr>
<td>Chiles and McMackin (1996)</td>
<td>Theoretical</td>
<td>Risks</td>
<td>TCE</td>
</tr>
<tr>
<td>Sharma (1997)</td>
<td>Theoretical</td>
<td>Theories</td>
<td>Social Exchange and Agency</td>
</tr>
<tr>
<td>Jones, Hesterly and Borgatti (1997)</td>
<td>Theoretical</td>
<td>Theories</td>
<td>Social Exchange and TCE</td>
</tr>
<tr>
<td>Poppo and Zenger (1998)</td>
<td>Field and Multiple case study</td>
<td>Theories</td>
<td>Resources and TCE</td>
</tr>
<tr>
<td>McKnight, Cummings and Chervany (1998)</td>
<td>Theoretical</td>
<td>Relationships</td>
<td>Relationship</td>
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<td>Laios and Moschuris (1999)</td>
<td>Field and Multiple case study</td>
<td>Outsourcing</td>
<td>Strategic</td>
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<tr>
<td>Ngwenyama and Bryson (1999)</td>
<td>Single case study</td>
<td>Strategy</td>
<td>TCE</td>
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STRATEGIC SOURCING: DEVELOPING A PROGRESSIVE FRAMEWORK FOR MAKE-OR-BUY DECISIONS
Abstract

**Purpose:** Make-or-buy decisions represent a critical dilemma faced by many firms. The appropriate decision between designing and manufacturing parts or services in-house, buying them from external providers or combining both is a fundamental firm process. This paper seeks to address this question by updating the traditional make-or-buy literature with new academic insights, developing a make-or-buy framework with a tool for its operationalization to help professionals evaluate sourcing decisions.

**Design:** First, a literature review of the principal theories and approaches about make-or-buy decisions is discussed. Second, the development of the make-or-buy framework is described and explained based on the results of qualitative interviews with practitioners and a set of interviews of an in-firm case study. Third, the results and the implementation of the framework are outlined.

**Findings:** This study not only validates the proposed framework through a set of in-firm make-or-buy decisions, but also provides a structure for its implementation and design a decision matrix with a pairwise comparison tool for helping practitioners to put the framework into practice.

**Implications:** This paper aims to contribute to the study of the make-or-buy literature in supply chain management through the graphical representation of why and how make-or-buy decisions are made. Interestingly, the paper presents relevant dimensions and factors to be studied and evaluates possible outcomes when approaching make-or-buy decisions.

**Originality/value:** The results reviewed suggest that practitioners should combine this framework with a comparison matrix and a multi-criteria decision analysis based on the TOPSIS methodology to assess strategic sourcing decisions.

**Keywords:** Make-or-buy decisions, decision-making, outsourcing, plural sourcing, hybrid sourcing, literature review
3.1 Introduction

The critical question practitioners face when making the decision between manufacturing their own products or buying them from external providers was studied in the past. However, it failed to consider hybrid and plural sourcing options with the combination of a practical tool for their operationalization. Whereas hybrid sourcing refers to procurement of the entire volume from a single mode that exhibits mixed governance characteristics, plural sourcing refers to the combination of insourcing and outsourcing simultaneously (Jacobides and Hitt, 2005; Park and Ro, 2011; Parmigiani, 2007; Puranam, Gulati and Bhattacharya, 2013). This mode of governance was not considered by many frameworks developed in the past like the one designed by Cánez, Platts and Probert (2000). Plural sourcing, also called “concurrent sourcing” or “make-and-buy” in the literature, is widely implemented by practitioners.

Additional to the historical and dichotomous make-or-buy perspective, decision makers should also take into account the hybrid and plural sourcing views, as well as the creation of strategic alliances. According to Doz, Prahalad and Hamel (1990), joint ventures provide low-cost, fast access to new markets by sharing risks and borrowing expertise from local partners. Instability of the alliance or joint venture may be influenced by the acquisition of local knowledge by the foreign partner.

Experts and decision makers want to know which factors may influence a firm's decision to buy a part or service rather than manufacture it internally and how relevant factors should be evaluated in order to take the right decision and avoid future problems and extra costs. Whereas many make-or-buy decisions are instinctive, and firms continue to make decisions on a piecemeal basis (McIvor, 2013), firms have limited resources and cannot afford to have all engineering and manufacturing resources in-house. Hence, make-or-buy decisions and their consequences got more attention because of their influence on the firm’s performance. Thus, an updated, efficient, comprehensive and practice-oriented framework to address make-or-buy decisions for either R&D or manufacturing activities validated with a real case study was required. In contrast to the majority of past works, this study addresses not only economic but also strategic-related criteria in resolving make-or-buy decisions in a structured and efficient manner. The rest of the paper is organized as follows: Section 2 analyzes the make-or-buy literature and develops a conceptual make-or-buy framework. In Section 3, a qualitative analysis of interviews with middle-level managers and an in-firm-case study are
explained. In Section 4, the proposed framework is described and validated through the case study. Then, trends from experimental evaluations and analyzes are presented in order to assess the effectiveness and efficiency of the proposed model in Section 5. Finally, the main conclusions and the topics related to this study are presented in Section 6.

3.2 Literature review

3.2.1 Previous make-or-buy frameworks

Previous make-or-buy literature has been researched in the past. For instance, Walker (1988) considered that activities should be insourced in order to avoid appropriation risks, technology diffusion and end-product degradation. In his view, the assessment of the strategic risk associated with the activity should be favourable to the organisation's competence in performing the activity as opposed to that of suppliers. While Venkatesan (1992) stated that manufacturing processes where external providers have a comparative advantage against the firm should be outsourced and core manufacturing processes should be insourced, Welch and Nayak (1992) argued that activities or services should be insourced whenever the process technology is mature and superior at the firm. Quinn and Hilmer (1994) supported the outsourcing decision when a high need for flexibility is required and insourcing when the need for flexibility is low. According to Apte and Mason (1995), it is necessary to form a strategic partnership with an external provider or invest to acquire the required competence whenever an activity has a high strategic importance and a low relative efficiency.

McIvor, Humphreys and McAleer (1997) developed one employing criteria like core competences, capabilities and costs for evaluating make-or-buy decisions. They highlighted the importance of comparing internal and external criteria. On the other hand, Sislian and Satir (2000) developed a sourcing framework based on four factors which were subcategorised into (1) primary factors, namely: competitive advantage and demand flexibility, and (2) secondary factors, which were process capability, process maturity and strategic risks. The same year Cánez, Platts and Probert (2000) developed a make-or-buy framework. Latterly, McIvor (2009) proposed a TCE-RBV combined theoretical framework and Brewer, Ashenbaum and Carter (2013) validated it and extended it with performance attributes. Recently, Brem and Elsner (2018) proposed a framework with two kinds of make-
or-buy decisions: one associated with production and quality function and the other associated with R&D activities.

3.2.2 Make-or-buy: Theoretical approaches

As has been done in the past by other researchers like Dibbern et al. (2004) with their theoretical foundations or Cánéz, Platts and Probert (2000) with their make-or-buy framework, this thesis summarises the main theories which may influence make-or-buy decisions. These theories are listed on a spreadsheet along with some detailed information about the year of publication, the author’s name, the methodology employed and key points of the related theory. The theories and insights were sorted out chronologically and are listed in Table 3-4 of Appendix I (3.8.2). The methodology employed for designing this table, as well as the description of the results, are not addressed in depth in this article, since they are the subject of another publication.

In addition to the theories categorised by Dibbern et al. (2004), this thesis has identified theories and insights concerning alliances, hybrid sourcing, plural sourcing, transaction cost economics (TCE), resource-based view (RBV) theories and make-or-buy frameworks. The review work began with the systematic identification of renowned academic journals in the field of make-or-buy decisions from the literature. A search for the keywords “make-or-buy” in the Proquest, Web of Science and Google Scholar academic databases was performed, following a database search methodology similar to the one adopted by Butkovic, Kauric, and Mikulic (2016). Articles and publications dealing with make-or-buy decisions were listed on a spreadsheet along with some detailed information about the year of publication, the author’s name, the methodology employed and key points of the related article. The electronic search was completed with a manual one, especially focused on tracing the papers cited in the bibliography of the previously selected articles. Articles fulfil the requirement of appearing in the databases mentioned above and were selected based on their journal impact and citation reputation. The interest of researchers and practitioners about the make-or-buy literature, and especially the literature favoring the “buy” decision, has increased over the last few decades. Make-or-buy decisions have been addressed from multiple viewpoints. Due to the increased relevance of resource theories in recent decades, this thesis has extended the two strands identified by Cánéz, Platts and Probert (2000) to four approaches.
The first approach tackles the make-or-buy question from a strategic perspective (Chandler, 1962; Porter, 1985; Quinn, 1980). Strategy is the determinant of the basic long-term goals of a firm, and the adoption of actions and the allocation of resources necessary for carrying out these goals (Chandler, 1962). Miles and Snow (1978) identified four business-level strategies: defender, prospector, analyzer, and reactor. Porter (1985) defined a five forces model which explains the strategic activities of a firm and proposes different perspectives, considering other factors besides cost reduction. Thus, innovation theories (Rogers, 1983) are taken into account within these four perspectives, and especially from a strategic viewpoint. Admittedly, the strategic perspective is intended to be interpreted to the strategic viewpoints, distinct from the resource-based view and transaction cost economics theories, because both incorporate also strategic perspectives.

The second approach aims to analyze the make-or-buy decision from a resource viewpoint (Barney, 1991; Penrose, 1959; Pfeffer and Salancik, 1978; Thompson, 1967). First, the resource perspective plays an important role, especially in the RBV theory (Barney, 1991) and the resource dependency theory (Pfeffer and Salancik, 1978). The RBV theory is a construct of competitive heterogeneity which can be applied for answering the question “Why do firms in the same industry vary systematically in performance over time?” According to RBV theories, this happens because internal capabilities and resources yield a competitive advantage. RBV adopts two assumptions in analysing sources: (1) firm resource heterogeneity and (2) firm resource immobility. There are four attributes of resources that lead to a competitive advantage: being valuable, rare, imperfectly imitable and non-substitutable. Second, the resource dependency theory states that firms depend to some degree on their external environment and external providers because they do not have all the resources they need. There are three core ideas in this theory: (1) social context matters; (2) organisations have strategies to enhance their autonomy and pursue interests; and (3) power is important for understanding internal and external actions of firms. Priem and Butler (2001) provided new insights for where and how the RBV can contribute, especially by complementary and integrated use of RBV together with other perspectives.

The third strand addresses the make-or-buy question from a performance viewpoint. Key performance indicators should be defined and make-or-buy decisions evaluated. In addition to this, relationship theories (Klepper, 1995; Kern, 1997) can play a relevant role in the third and fourth perspectives. The research undertaken by Brewer, Ashenbaum and Carter (2013)
validated and further developed the framework proposed by McIvor (2009) with performance attributes.

The fourth viewpoint approaches make-or-buy decisions from an *uncertainty and opportunism perspective*. TCE was established by Williamson (1975, 1981 and 1985) who stated in 1975 that the firm offers major governance over opportunism. Later on, Slater and Spencer (2000) emphasized the role of uncertainty as its core assumption. In fact, vertical integration stems as a preferred assessment to avoid contractual problems with external providers. The main theoretical argument of this theory is that the conditions of the transaction would lead to its internal, hybrid, or external governance. It has two important fundamental behavioural assumptions: (1) bounded rationality (Simon, 1957); and (2) opportunism. This risk of opportunism is a factor considered in the game (Fudenberg and Tirole, 1990) and agency (Eisenhardt, 1989) theories, which intend to safeguard firms from possible risks. When applied to make-or-buy studies, it posits that firms need to consider both production costs and transaction costs for an outsourcing negotiation. These strands are integrated into the make-or-buy assessment approach and drawn in Figure 3-4 of Appendix 3.8.1. A decision matrix has been developed based on the four perspectives identified from the literature and the framework designed by McIvor (2009). In this version, this thesis has developed the TCE and RBV theories from previous frameworks, taking into account strategic values and performance characteristics.

### 3.3 Data collection methods

In order to develop, adapt and validate the proposed conceptual framework, a number of interviews with practitioners and middle-level managers, and a set of interviews of an in-firm case study were undertaken. The interviews, the design of the interviews, the analysis of the transcripts and the incorporation of the findings into the framework are described here. An analysis of the recent make-or-buy literature was performed and served as the basis for preparing and designing the interviews. From the beginning of data collection, it’s started to decide which information is relevant. Hypotheses collected from this literature review were contrasted with practitioners’ opinions. Qualitative data analysis is conducted following the Miles and Huberman (1994) methodology, mainly: (1) Data reduction. In this phase, the mass of qualitative data obtained through interview transcripts, observations, notes, etc. is reduced and organized, and non-relevant data is discarded. (2) Data display. The analysis from mass
data is displayed in the form of tables, charts and other graphical formats as a continual process. (3) Conclusion. The analysis review is the basis to begin to develop conclusions and to verify and validate the study. The meanings from the data are tested for their plausibility and their validity.

3.3.1 Interviews with practitioners

Qualitative interviews are held with practitioners at supplier sites located in Europe. A qualitative research is a better fit for the types of questions required to collect the expected answers. The interviews highlighted the essential importance of practitioners when developing the framework. In contrast to the research conducted by Cánez, Platts and Probert (2000), who only considered the industrial context in the UK area for developing the framework, practitioners located in Italy, the UK, Germany, Slovakia, the Netherlands, Belgium, Hungary and Poland are interviewed. The 20 analyzed firms are a convenient sample, since the author has professional relationships with them. Information about the 20 firms analyzed between 2016 and 2017 is drawn in Table 3-1. Practitioners are selected based on their experience on dealing with make-or-buy decisions and outsourcing transactions, who are mainly supply chain responsible persons. Defined standardize interviewees based on a general methodology relied on a pre-designed questionnaire were undertaken in order to avoid bias and to be able to approach a qualitative comparison. Semi-structured interviews with middle-level managers were conducted. An interview questionnaire based on the literature was designed and used as an interview guide (see Appendix II, 3.8.3). A previous brainstorming was performed using the questionnaire from Appendix 9.2.2 “Survey: Strategic Sourcing”.

One interview was performed per firm as part of an on-site supplier audit taking over one hour and mainly covering the following topics:

- details of the interviewee
- areas related to make-or-buy decisions
- triggers for make-or-buy decisions
- criteria to be considered during the make-or-buy decision process
- functions involved in the make-or-buy decision process
- relevant criteria for the “make” and “outsourcing” decision taken at the organisation
- relevant financial elements during the “make” and “buy” decision process
- strengths and weaknesses of current and past decisions
• lessons learned and suggestions of current and past decisions

Table 3-1. Characteristics of interviewed firms

<table>
<thead>
<tr>
<th>Firm</th>
<th>Sector</th>
<th>Plant</th>
<th>Revenue</th>
<th>No. of employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Electronics manufacturing</td>
<td>Slovakia</td>
<td>€5-10m</td>
<td>200</td>
</tr>
<tr>
<td>B</td>
<td>Assembling</td>
<td>Germany</td>
<td>€1-5m</td>
<td>170</td>
</tr>
<tr>
<td>C</td>
<td>Turning</td>
<td>Italy</td>
<td>€37-40m</td>
<td>350</td>
</tr>
<tr>
<td>D</td>
<td>Die casting</td>
<td>Italy</td>
<td>€5m</td>
<td>18</td>
</tr>
<tr>
<td>E</td>
<td>Turning, drilling, milling</td>
<td>UK</td>
<td>£1.5m</td>
<td>24</td>
</tr>
<tr>
<td>F</td>
<td>Machining</td>
<td>UK</td>
<td>£50m</td>
<td>328</td>
</tr>
<tr>
<td>G</td>
<td>Turning</td>
<td>Germany</td>
<td>€5-10m</td>
<td>50-99</td>
</tr>
<tr>
<td>H</td>
<td>Housing, metal processing</td>
<td>Germany</td>
<td>€5-10m</td>
<td>50-99</td>
</tr>
<tr>
<td>I</td>
<td>Metal powder forming</td>
<td>Netherlands</td>
<td>$5-10m</td>
<td>20-50</td>
</tr>
<tr>
<td>J</td>
<td>Thermosets, plastics</td>
<td>Belgium</td>
<td>$100-500m</td>
<td>120</td>
</tr>
<tr>
<td>K</td>
<td>Housing, metal processing</td>
<td>Germany</td>
<td>€50-100m</td>
<td>600</td>
</tr>
<tr>
<td>L</td>
<td>Sounders, loudspeakers</td>
<td>Italy</td>
<td>€13m</td>
<td>50</td>
</tr>
<tr>
<td>M</td>
<td>Electronics manufacturing</td>
<td>Germany</td>
<td>€140m</td>
<td>750</td>
</tr>
<tr>
<td>N</td>
<td>Electronics manufacturing</td>
<td>Germany</td>
<td>€88m</td>
<td>700</td>
</tr>
<tr>
<td>O</td>
<td>Electrification</td>
<td>Hungary</td>
<td>$2.7b</td>
<td>13,500</td>
</tr>
<tr>
<td>P</td>
<td>Thermosets, plastics</td>
<td>Hungary</td>
<td>€34m</td>
<td>450</td>
</tr>
<tr>
<td>Q</td>
<td>Die casting</td>
<td>Poland</td>
<td>€10-25m</td>
<td>1,500</td>
</tr>
<tr>
<td>R</td>
<td>Turning</td>
<td>Italy</td>
<td>€11.5m</td>
<td>50</td>
</tr>
<tr>
<td>S</td>
<td>Electrification</td>
<td>Germany</td>
<td>$33,828m</td>
<td>136,000</td>
</tr>
<tr>
<td>T</td>
<td>Die casting</td>
<td>Italy</td>
<td>3.8m</td>
<td>40</td>
</tr>
</tbody>
</table>

Source: case study

3.3.1.1 Findings and results from the interviews with practitioners

A number of issues arose from the analysis of the interviews. First, the principal triggers to undertake make-or-buy decisions were identified: (1) need for quality or delivery improvement; (2) need for proximity to markets; (3) need for cost or service improvement; (4) need for a competitive advantage; (5) new product or service introduction; (6) need for resources and skills at the firm; and (7) need for demand flexibility. Some of these triggers where mentioned in the past and their importance is supported by the practitioners involved in this research.

Second, the main factors considered for make-or-buy decisions were noted, for instance sales growth, profitability, costs reduction, manufacturing flexibility, core or non-core activity, technical differentiation, resource position, performance and the potential for opportunism. The “core or non-core activity” factor is a key decision criterion which strongly influences the
make-or-buy decision. This relevance was noted in the discussion with the interviewees. As opposed to low-performance non-core activities, high-performance core or strategic activities should be retained in-house, if possible, in most cases. Data was summarised on an excel sheet and incorporated later in the preliminary framework. Data from the framework was continuously modified and updated. Third, key characteristics were highlighted on the excel sheet. The need for standardising the framework was always kept in mind. Thus, factors and triggers relevant for unusual circumstances and special use cases were remarked.

Finally, key issues related to the make-or-buy decision process were noted, such as the people involved, the durability of the project, and the difficulties found. A main differentiation can be observed between firms depending on their size, structure and internationalisation. In contrast to medium and small-sized firms, large and global players operating internationally have their strategic functions like procurement centralised. Local partnerships and long-term relationships are preferred once certain services have been outsourced. Mutual trust and clear and open bidirectional communication with external providers are key factors for outsourcing services like surface treatment, powder coating or assembling activities. The findings recorded in this section were also considered for improving the framework design.

### 3.3.2 In-firm case study

In order to create a robust framework and a tool to help their functionality, several issues required to be addressed. First, a better understanding of how make-or-buy decisions were being made in practice was needed. Second, a better understanding of the lessons learned and improvement potentials collected from the interviews had to be analyzed and prioritised. Third, a clear understanding of the interrelation between the firm, third parties and the triggers, factors and possible outcomes of each approach to make-or-buy decisions had to be identified. In order to do this, after the interviews with practitioners, twenty-four past and current make-or-buy decisions were analyzed and reviewed using the framework (see Table 3-2).
<table>
<thead>
<tr>
<th>MoB</th>
<th>Main triggers</th>
<th>Main factors</th>
<th>Sourcing location</th>
<th>Sector</th>
<th>Sourcing strategy</th>
<th>Production output</th>
<th>R&amp;D output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Need for quality improvement</td>
<td>Defects, profitability</td>
<td>Germany, national &amp; Slovak</td>
<td>Electronics manufacturing</td>
<td>Multiple</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>2</td>
<td>Need for resources</td>
<td>Resources, profitability</td>
<td>Abroad, Czech Republic</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>3</td>
<td>New product introduction</td>
<td>Supplier process flexibility</td>
<td>Abroad, Slovenia</td>
<td>Electronics manufacturing</td>
<td>Single</td>
<td>Investing from external provider</td>
<td>Hybrid sourcing</td>
</tr>
<tr>
<td>4</td>
<td>Need for resources</td>
<td>Resources, profitability</td>
<td>Abroad, Poland</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Forming an alliance</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>5</td>
<td>Need for resources</td>
<td>Resources, profitability</td>
<td>Germany, local</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>6</td>
<td>Need for resources</td>
<td>Resources, profitability</td>
<td>Germany, local</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>7</td>
<td>Need for resources</td>
<td>Resources, profitability</td>
<td>Germany, local</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>8</td>
<td>Need for demand flexibility</td>
<td>Manufacturing flexibility</td>
<td>Germany, local</td>
<td>Assembling</td>
<td>Multiple</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>9</td>
<td>Need for demand flexibility</td>
<td>Manufacturing flexibility</td>
<td>Germany, local</td>
<td>Assembling</td>
<td>Multiple</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>10</td>
<td>Need for demand flexibility</td>
<td>Manufacturing flexibility</td>
<td>Germany, local</td>
<td>Surface treatment</td>
<td>Multiple</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>11</td>
<td>Need for demand flexibility</td>
<td>Manufacturing flexibility</td>
<td>Germany, national</td>
<td>Surface treatment</td>
<td>Multiple</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>12</td>
<td>New service introduction</td>
<td>Contract manufacturers’ capability</td>
<td>Germany, local</td>
<td>Surface treatment</td>
<td>Single</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>13</td>
<td>Need for cost or service improvement</td>
<td>Contract manufacturers’ capability</td>
<td>Germany, local</td>
<td>Metal powder forming</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>14</td>
<td>New product introduction</td>
<td>Technical differentiation, core activity</td>
<td>Germany</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to enable in-house manufacturing</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>15</td>
<td>New product introduction</td>
<td>Technical differentiation, core activity</td>
<td>Germany</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Investing to enable in-house manufacturing</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>16</td>
<td>New product introduction</td>
<td>Sales growth</td>
<td>Germany, national</td>
<td>Electronics manufacturing</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>Hybrid sourcing</td>
</tr>
<tr>
<td>17</td>
<td>New product introduction</td>
<td>Supplier process maturity</td>
<td>Germany, national</td>
<td>Electronics manufacturing</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>Hybrid sourcing</td>
</tr>
<tr>
<td>18</td>
<td>Need for cost or service improvement</td>
<td>Manufacturing flexibility, cost reduction</td>
<td>Abroad, India &amp; Germany</td>
<td>Housing, metal processing</td>
<td>Multiple</td>
<td>Making (subsidiary) &amp; buying</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>19</td>
<td>New tooling introduction</td>
<td>Resources, profitability</td>
<td>Germany, national</td>
<td>Tooling</td>
<td>Single</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>20</td>
<td>Need for delivery &amp; cost improvement</td>
<td>Competitive advantage, cost reduction</td>
<td>Abroad, Poland</td>
<td>Housing, metal processing</td>
<td>Single</td>
<td>Investing to buy from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>21</td>
<td>Need for cost improvement</td>
<td>Cost reduction</td>
<td>Germany, national</td>
<td>Electronics manufacturing</td>
<td>Single</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>22</td>
<td>New product introduction</td>
<td>Supplier technology &amp; manufacturing</td>
<td>Germany, local</td>
<td>Housing, metal processing</td>
<td>Single</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>23</td>
<td>Need for demand flexibility</td>
<td>Manufacturing flexibility, cost reduction</td>
<td>Germany, local</td>
<td>Housing, metal processing</td>
<td>Multiple</td>
<td>Buying from external provider</td>
<td>In-house manufacturing</td>
</tr>
<tr>
<td>24</td>
<td>New product introduction</td>
<td>Supplier process maturity</td>
<td>Germany, national</td>
<td>Thermosets, plastics</td>
<td>Single</td>
<td>Buying from external provider</td>
<td>Hybrid sourcing</td>
</tr>
</tbody>
</table>

Source: case study
We collected information on how make-or-buy decisions were approached in several cases in order to undertake the in-firm case study. The information was obtained from a leading NEC, CEC, ATEX, GOST Inmetro and IECEx-certified manufacturer of electrical products. This firm, based in Germany, is a global player with 1,690 employees and a €280.1 million turnover (key figures from February 28th 2019) (Employees 2018: 1,690; 2017: 1,763; 2016: 1,788) (Turnover (million) 2018: €280.1; 2017: €268.5; 2016: €286.6).

The main criteria for selection were that the firm had recently assessed make-or-buy decisions and the convenience of the author with the firm. The case study was carried out using evidences from multiple sources, such as make-or-buy decision assessments, final reports and project plans, for increased validity and reliability (Yin, 1994 and 2018). The case study will also be useful to refine the framework and illustrate how to use it. A questionnaire with a preliminary framework was designed for the in-firm case study interviews, which covered the abovementioned topics and the discussion of the preliminary framework, the stages taken into account during the make-or-buy decision and an evaluation of the theories and hypotheses summarised from the make-or-buy literature review. This questionnaire is based especially on the survey designed by Parmigiani (2007) (see Appendix III, 3.8.4). Interviews were held with supply chain managers.

3.3.2.1 Findings and results from the case study

From the case study it was observed that firms preferable take make-and-buy strategies for complete solutions and services, but not for manufacturing single parts or components. However, hybrid sourcing is not commonly used by practitioners; firms can choose this option to get into new markets or for strategic reasons to increase their product brand portfolio. For instance, the firm based in Germany chose this option to supply their clients with particular cable glands with ATEX certification from a supplier who already certified these products and the firm sell them under its own brand’s label name. In the past, individual experts have made the decision to pursue either a make or a buy strategy as a de-centralized activity at the middle-level manager, with little oversight of a strategic central sourcing function. The firm has a partly structured process for addressing make-or-buy decisions. However, there were clear problems with the control of documentation and the way make-or-buy decision processes were conducted and documented depending on the participants involved. In addition to this, interviewees proposed potential improvements to standardize the process. The involvement of a multidisciplinary team was mentioned by all interviewees. The
firm manages its make-or-buy decisions from a centralized and strategic department and mostly is buying raw material, components and services for its production site. For instance, R&D output column refers to the decision between insource or outsource the development of R&D activities of a specific product or service. A key input collected from the analyzed case study is the need to periodically evaluate the assessed make-or-buy decisions, document all changes requested in writing and reassess them if appropriate. Furthermore, the need for four stages in the decision-making process was identified in the study: (1) planning; (2) data collection and analysis; (3) performance evaluation; and (4) improvement.

### 3.4 Proposed framework

The framework presented in this section has been developed using the data collected from the literature review, the qualitative interviews with practitioners described in Section 3.3.1 and a set of interviews of an in-firm case study explained in Section 3.3.2. Hence, the framework is in accordance with the guidelines proposed by Miles and Huberman (1984) and their implementation through Cánez, Platts and Probert’s (2000) framework pointed out in Section 3.2.2. The framework explains graphically the main dimensions to be studied – the key factors, and the possible triggers and outcomes derived from make-or-buy decisions. The developed framework defines which dimensions are more important, which relationships are likely to be most meaningful, and what information should be collected. Four main strands identified in Section 3.2.2 and a number of factors observed in Section 3.3.1.1 were suggested within these clusters, including: (1) demand flexibility; (2) single or multiple source strategy; (3) trade implications; (4) technical differentiation; (5) competitive advantage; and (6) core / non-core product or service for the strategic value area. In opposite to Amit and Schoemaker (1993) who detailed the constructs of the resource-based view in combination with the behavioral decision theory, this framework prioritizes the evaluation of key performance indicators during the make-or-buy decision. Within the resource position area, the following factors were prioritised, mainly: (1) resources / capabilities available; (2) skills and know-how available; (3) assets available; (4) process maturity; (5) support systems; and (6) technology and manufacturing processes. While Shishank and Dekkers (2013) detailed a framework for new product development phase, the results from the case study confirmed that the most of the make-or-buy decisions happened during the manufacturing phase. Thus, costs saving strategies are pursued.
For the performance area, the following factors were noted: (1) conversion costs; (2) manufacturing flexibility; (3) contract cost reduction; (4) defective parts per million / ppm; (5) delivery reliability; (6) overall equipment effectiveness; (7) asset utilisation; (8) variant reduction; and (9) sustainability punctuation. In the potential for opportunism area, the following factors were proposed: (1) information asymmetry; (2) flexibility; (3) quality defects; (4) delivery delays; (5) cost increases; (6) skills appropriation; (7) insufficient corporate social responsibility (CSR) value; and (8) complexity of the relationship. Operational performance was regarded as an independent area, as an input concerning the improvement potential perceived by decision makers interviewed during the case study analysis. In fact, a performance assessment was a critical step missing in unstructured make-or-buy decision processes.

Possible influences from the external environment on the process are taken into account and included in the framework. As it was verified at the case study, the framework illustrated in Figure 3-1 validates the efficiency of the previous Cànez, Platts and Probert’s (2000) approach, increasing the process’s visibility for decision makers with the drawn possible outcomes. External forces on which the firm’s influence is minimal can activate triggers for the make-or-buy analysis and are illustrated in the framework. Therefore, firms can take advantage of external providers’ expertise and a contractual cost reduction thanks to the economy of scale. In contrast to the existing make-or-buy decision-making approaches, the framework provides a practical and target-oriented overview, where decision makers can evaluate possible outcomes of the assessment from the start of the project. Interestingly, the graphical visualization of the framework allows academics and practitioners to locate the make-or-buy process for both R&D and manufacturing activities.

A majority of studies highlighted the advantages of outsourcing for assessing non-core services and the vertical integration approach as a mechanism to safeguard core services and core products. For instance, in September 2017 the firm ABB announced the acquisition of the business unit of General Electrics, Industrial Solutions (Electrification-Switchgear-division). The main strategic goal was to successfully expand its market share in the US market and obtain the rights to use the GE brand.
Figure 3-1. Make-or-buy framework

Source: case study
In addition to the one-page graphical illustration, a tool with a decision matrix was developed oriented towards the guidelines of the pairwise comparison technique (Thurstone, 1927) and the technique for order preference by similarity to ideal solution (TOPSIS) method. The pairwise comparison technique is widely employed to handle subjective and objective judgements in multi-criteria decision making, especially as a method to determine the weighting of criteria (Kou, Ergu, and Shang, 2014). The TOPSIS method has been dealt with multi-criteria models for complex decisions and multiple attribute models for the most preferable choice.

TOPSIS is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon (1981) with further developments by Yoon (1987) and Hwang, Lai and Liu (1993). This tool combines the pairwise comparison matrix and the TOPSIS method to enhance the tool’s reliability in decision-making processes. The combination of both techniques enables the implementation of the framework. Interestingly, the criteria for the practical use of the tool are defined as follows: (1) determining the weighting of criteria through a pairwise comparison matrix (PCM); (2) calculating the relative closeness to the ideal solution with a decision matrix based on the TOPSIS method; (3) determination of the weighting of decision makers; and (4) the criteria for the functionality of the tool (see Table 3-3). The weight of decision maker levels is set as follows according to the Boran, Genç, Kurt and Akay’s (2009) research: DM1 for supply chain managers and project leaders is 0.406; DM2 for R&D, industrial engineers and purchasers is 0.238; and DM3 for quality responsible is 0.356, so that the total of the weighting is 1.
Table 3-3. Criteria for the operationalization of the tool

**Key:**

1. **Pairwise comparison assessment:**
   - 2 More important
   - 1 Equally important
   - 0 Less important

2. **Decision matrix assessment:**
   - 5 The Excellence is achieved
   - 4 The requirements are fully met
   - 3 The requirements are almost completely fulfilled: it can be improved in the short term
   - 2 The requirements are only partially met and/or improvement is only expected in the medium term
   - 1 The requirements are not met, improvements are not expected

3. **Determine the weighting of decision makers:**

<table>
<thead>
<tr>
<th>Language terms</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM1 Very important</td>
<td>0.406</td>
</tr>
<tr>
<td>DM2 Medium</td>
<td>0.238</td>
</tr>
<tr>
<td>DM3 Important</td>
<td>0.356</td>
</tr>
</tbody>
</table>

4. **Recommendations for results evaluation:**

<table>
<thead>
<tr>
<th>Potential for make-or-buy decisions:</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>High potential (Approved and preferred)</td>
<td>100%-80%</td>
</tr>
<tr>
<td>Medium potential (Approved; decision is recommended)</td>
<td>80%-60%</td>
</tr>
<tr>
<td>Low potential (decision is recommended, low risk involved)</td>
<td>60%-40%</td>
</tr>
<tr>
<td>Recommended, high risk involved (proceed with caution or redefine your approach)</td>
<td>40%-20%</td>
</tr>
<tr>
<td>Decision not recommended</td>
<td>20%-0%</td>
</tr>
</tbody>
</table>

Source: case study

In the analysis, scores between 100% and 80% indicate that the assessment is highly recommended and scores between 80% and 60% indicate that decision is recommended, without risks involved. If scores between 60% and 40% are obtained the decision is recommended (although low risk exists), whereas the risk for the assessment is high when scores are between 40% and 20%. Finally, the decision for scores lower than 20% is not recommended. If several source alternatives obtain scores within the 100%-80% range, make-and-buy decisions, hybrid sourcing and alliance options should be evaluated according to the key objectives defined in the tool (see Figure 3-5 in Appendix 3.8.1). The project leader, assigned for the make-or-buy decision, planned, coordinated and led activities to ensure that tasks were accomplished according to the milestone plan and all key deadlines were met. The project was documented on a project sheet containing the following sections: (1) general information; (2) key objectives; (3) required criteria (see Figure 3-6 in Appendix 3.8.1); (4) pairwise comparison assessment (Figure 3-2); and (5) TOPSIS decision matrix sheet (Figure 3-3).
Figure 3-2. Pairwise comparison

Source: case study

Figure 3-3. Decision matrix assessment (includes TOPSIS decision matrix assessment)

Source: case study
3.4.1 An illustration of the framework using a set of case studies

This section shows how this framework and its content are aligning with the considerations of the discussed in-firm case study. The triggers, the external elements which activate the triggers, the areas and factors and the final outcomes of the case study are discussed in this section.

3.4.1.1 First MoB case study

Firm and environment

The first make-or-buy (MoB) case study was related to the manufacturing of electronic isolators involving PCB (printed circuit board) assembly and painting and the respective functional and in-circuit tests. The R&D and the manufacturing of those products were performed in the firm. The high number of quality issues in the production line and the high failure rate of the manufactured isolators made upper management aware of this issue, which led to force quality improvements and pressure to reduce rework costs.

Triggers

From the analysis of the case, it was clear that the main trigger for the make-or-buy review was the need for quality improvement and the reduction of rework costs. When the manufacturing process was examined, three needs were identified: investment in high-tech machinery, process standardisation and training of the people involved. The high number of variants and their complexity hindered the process and required further resources which were not available at the firm. As a result of this, a multidisciplinary team was set up to conduct the make-or-buy analysis.

Considerations for the make-or-buy decision

Strategic value. These parts provide a clear competitive advantage and have a relatively high strategic value for the firm because of their technical differentiation against competitors. This was a relevant factor, together with the need for a profitability increase, a multiple sourcing strategy and demand flexibility.

Resource position. The firm’s low resource position required additional investment in high-tech assets and internal resources, but other important considerations were the availability of contract manufacturers in the market offering advanced technology and expertise in similar industrial processes. Hence, given the small volume of parts manufactured per year, the high
investment required would not be recovered by the firm. Special certifications and compliance with technical requirements would require a support system and team for potential future external providers if it were decided to outsource the manufacturing process.

Performance. The internal process performance was low and partly not measured because of the process was not mature. The definition of key performance indicators (KPIs) to monitor the process was essential to evaluate the outcome decision. Contract cost reduction indicators, delivery and quality performance figures, asset utilisation and variant reduction were taken into account. The firm could take advantage of the economy of scale by reducing its manufacturing costs.

Potential for opportunism. Information asymmetry was a clear problem which was not totally identified during the make-or-buy decision-making process because of the firm failed to clearly and comprehensively document all specifications for external providers. The risk for an increase in quality defects, purchasing costs, delivery delays and a complex relationship with external providers were also factored in. Additionally, monitoring and auditing activities would be required in order to support the external provider until the process had been matured at its site.

Final outcome
In this case study, the final decision was to switch from manufacturing the part in-house to source the activity out split for two external providers. The volume of the activity was equally outsourced by approximately 50% of the revenue between both external providers. The firm got a better negotiation position with them because of the possibility to assign each stage of the process to one or other external provider. Fact that was feared by the external providers.

Lessons learned
According to interviewees, the make-or-buy decision process could be improved if all drawings, test specifications, control plans and FMEAs (Failure modes and effects analysis) were previously available and clearly documented. Specifications were only written in the German language, which created some misunderstandings for one external provider located abroad. Many test criteria were not clearly documented, leading to misunderstandings between the parties. A change process for outsourced products was not implemented, which gave rise to many unexpected costs as a result of the high number of product change requests. Interestingly, asymmetry and poor information issues could be avoided. It’s observed that firms performed weakly on the control of the outsourced activities (Dekkers, 2011).
3.4.1.2 Second MoB case study

Firm and environment
The second MoB case study was related to the manufacturing of a plastic part, involving injection moulding, ultrasonic welding and testing processes. It was the first time this part was being manufactured in the firm. The injection moulding process could be performed there, but the firm faced two major obstacles: the lack of capacity and the required investment in an ultrasonic welding machine. From the beginning, having a qualified external provider from the firm’s pool in charge of all processes was the option preferred by line managers. R&D employees, on the other hand, were mostly in favour of in-house control of the process.

Triggers
From the analysis of the case it became evident that there were two main triggers for the make-or-buy review. First, the introduction of the new product questioned the best performance and best cost reduction possibilities comparing the internal manufacturing costs with those involved in purchasing the part from an external provider. Second, the firm’s moulding production facilities were already at full capacity and no more resources were available, which led the firm to consider a make-or-buy decision for the complete pack of processes and services.

Considerations for the make-or-buy decisions
Strategic value. The strategic value of the part is medium, as its functionality can pose a threat to core activities. A single source strategy was favoured in order to reduce double tool investment costs. Profitability and sales growth were also important considerations.

Resource position. The lack of capacity for moulding production and the firm’s intention to avoid more investments and increase internal resources influenced the decision to outsource this process to an existing and known external provider. The provider, located abroad, manufactured other injection moulding parts for the firm. This new part required ultrasonic welding, which was a process the provider had never undertaken; the provider, however, agreed to perform it and acquire the welding machine and the skills needed.

Performance. Performance was high, as the cost reduction involved in outsourcing the part was expected to be higher than that for in-house manufacturing. In order to avoid delivery delays and quickly meet an increased demand, both firms signed a frame contract to reserve finished stocks in the provider’s warehouse with the possibility to receive new parts in one
working day. The manufacturing process at the provider’s site was set up and the ultrasonic welding process had to be monitored until it reached a mature phase. Delivery, asset utilisation and quality performance figures were taken into account.

Potential for opportunism. During the assessment, an increase in quality defects had not been anticipated, despite the fact that the provider’s expertise in the welding process was still limited. A second source strategy was not considered, which could lead to a production shutdown at the firm in the event of non-delivery by the provider and the derived extra costs to the firm. The risk for an increase in contract costs was also taken into account. The provider was until then classified as an A-provider, which is the best rating in the ABC external provider assessment category established at the firm. Additionally, monitoring and auditing costs would be required in order to support the external provider until the process had been matured and stabilised at its plant.

Final outcome
In this case study, the whole manufacturing process was outsourced to one existing provider. During the assessment, the skills and abilities of the provider performing the ultrasonic welding process were overestimated and many defective parts were delivered as a result.

Lessons learned
According to interviewees, the provider did not properly understand the functionality of the part. Hence, the language barriers and the long distance to the provider’s plant, which hindered the support and monitoring of the activity, had a significant impact on performance in this case study. The risk to core activities was not thoroughly considered during the assessment phase. Other providers were neither consulted nor taken into account. Finally, the manufacturing process was insourced as the firm understood the importance of having the process under its own control.

3.4.1.3 Third MoB case study

Firm and environment
The third MoB case study was related to the manufacturing and development of new electronic amperemeters from the concept phase, led by the R&D department, including manufacturing, testing and certification procedures. The firm had worked with external providers in the past to manufacture other electronic devices. As the results had been positive,
a team was formed to study the viability of the new project in cooperation with one of the providers from the firm’s pool.

**Triggers**
The main trigger for the make-or-buy review was the introduction of the new product with the best performance. The shortage of resources and skills at the firm and the pressure to reduce time to market led the company to assess the feasibility of developing this new product family in cooperation with a long-term provider. This provider was specialised in similar products, but applied to other industrial fields.

**Considerations for the make-or-buy decisions**

**Strategic value.** This family of parts will be strategic for the firm to expand its product offer for the coming years. The products will allow the firm to gain a competitive advantage, especially in terms of technical differentiation from competitors. Profitability performance, capacity for sales growth, trade implications and single source criteria were important considerations.

**Resource position.** The resource position of the firm regarding this product family is low. Hence, it was preferred to look for cooperation to take advantage of the provider’s expertise and develop a high-technology product. Other positive factors included the better position of the contract manufacturer’s capability and the special and positive cooperation with the provider in the past. Interestingly, the firm shared opportunities and risks with the provider in this special way of cooperation. The manufacturing activities would be outsourced as the manufacturing facilities and assets were already available at the external provider’s plant, where the firm could also take advantage of the economy of scale.

**Performance.** Contractual cost reduction, asset utilisation and overall equipment effectiveness were important considerations. Delivery and quality performance indicators were set up and could be monitored throughout the product’s lifecycle.

**Potential for opportunism.** The potential for opportunism was low based on the positive results in the past. However, as a safeguarding mechanism, the firm signed contractual agreements, like an R&D cooperation contract, a quality assurance agreement and a purchase contract. Additional monitoring mechanisms were already planned, such as a regular audit plan at the provider’s site and regular meetings and conference calls with the provider. Possible delivery delays, cost increases and skills appropriation were taken into account.
**Final outcome**

In the end, hybrid sourcing was adopted for the R&D activities and the manufacturing processes were outsourced. The single source strategy would allow the external provider to achieve a better negotiation position in the future and the firm would become highly dependent on the provider’s services. However, the firm’s strategy is built on a long-term relationship with the provider, based on mutual trust and open bidirectional communication. Additional variants may be developed in the future.

**Lessons learned**

According to interviewees, the make-or-buy decision was correct. However, the decision-making process could have been better documented and the option to hire expert R&D employees to keep the know-how in-house for the future was not considered. No additional studies were conducted to analyze the results of the assessment with a different outcome.

### 3.5 Discussion

Why is a make-or-buy decision a dilemma for firms? The difficult choice of whether to keep key functions, manufacturing or R&D activities in-house or outsource them has taken centre stage in firms. Firms can reach their own strategy and goals by saving costs and increasing profits through resolving make-or-buy decisions in a proper manner. Is it merely a decision how to source processes or components (parts, materials)? It’s not only a merely decision, it’s an established process within the firm. This paper contributes to spread out the academic understanding and practitioners’ knowledge by means of a framework and its operationalization. Particular attention is paid to the assessment and implementation of the framework via the developed tool enabling practitioners and academics to visualise the possible outcomes of make-or-buy assessments. The main figures of the twenty-four MoB decisions were documented and described using the framework. Only one of them was described in detail because of the paper’s size limitations. Besides the traditional pure sourcing strategy, other options are considered: plural sourcing strategies, hybrid sourcing and the formation of alliances. Hybrid sourcing is preferred when a great degree of cooperation and coordination between firms and external providers exists. External factors derived from the power and politics theories (Pfeffer, 1981 and 1982) can influence these approaches.
In plural sourcing, the combination of complementarities and constraints determines the optimal mix of internal and external sourcing. In addition to this, when the effects of the combination of both forces are equal to the effects of transactional hazards, plural sourcing is suggested. Even one of the most significant conclusion for practitioners concerns the need to design a structured make-or-buy decision process was already studied particularly in change management by Boer and During (2001), this study validates the importance of involving a multidisciplinary team and a project leader in charge of carrying out the make-or-buy assessment, allocating timescales and responsibilities. Also, the fit between the required characteristics of both the people conducting the process their perception of the product’s requirements, the make-or-buy process, and the way these perceptions are effected in the organization of the process are confirmed. The empirical results support the findings from Medina-Serrano, González-Ramírez and Gascó- Gascó (2018) concerning the relevance to evaluate the will to collaborate and joint problem solving in order to improve the partnership on outsourcing transactions.

The MoB decisions analyzed within this case study suggest that the framework is comprehensive and includes the key considerations highlighted in the interviews, offering insights about possible outcomes. As observed in the case study, while the relevance of business strategy is greater than or equal to that of economic factors, the risks involved in product supply chains are quite relevant. What are the main reasons for outsourcing? The outsourced area was a major problem for the firm in the past, partly because of the small volume of parts needed. The wish to sustain a multiple source policy, reduce costs, improve flexibility, exploits management’s expertise of contractors, avoid investment and outsource non-core activities to focus on core activities are some of the reasons for outsourcing provided in the case study. What costs are more relevant for the “buy” analysis? Increased purchasing expenses, the purchase price of the part, transportation expenses, any service or quality-related follow-up costs, complaint costs, receiving and inspection expenses, future pricing proposed by the provider, costs that the firm would keep incurring in the future, ongoing costs, one-time costs and auditing costs were considered. What financial factors are relevant in an organisation during the “make” decision process? Raw material costs, invested capital, labour costs, overhead costs and poor information were taken into consideration.
3.6 Conclusion

The research presented in this paper has significant theoretical and practical implications in the supply chain area in general and procurement management in particular, extending past versions of multi-criteria decision-making. Although past literature reviews provide valuable results, they were based upon the assessment of make-or-buy decisions failing to consider plural sourcing, hybrid sourcing or forming alliances. This paper aims to contribute to the study of the make-or-buy literature in supply chain management through the graphical representation of why and how make-or-buy decisions are made. Interestingly, the paper presents relevant dimensions and factors to be studied and evaluates possible outcomes when approaching make-or-buy decisions. The proposed framework is verified and validated by the internal released and implementation in the aforementioned firm based in Germany. Interestingly, this framework seems to extend, update and validate the proposed framework from Cánez, Platts and Probert’s (2000). In contrast to their approach, this framework can be applied by practitioners and academics through its implementation into the pairwise and decision matrix tools. The results support the Shishank and Dekkers’ (2013) statement that a structured and standardize process is required in order to avoid resolving make-or-buy decisions under the conditions of inaccurate and incomplete information.

Due to the contradictory prescriptions of the McIvor (2009) and Brewer, Ashenbaum and Carter (2013) frameworks, the presented framework not only includes relevant factors to be considered, but also provides a structure to investigate these factors and design a practical decision matrix with a pairwise comparison to put the framework into practice. This is supported by the make-or-buy decision-making processes reviewed in the in-firm case study. Additionally, it takes into account the need to determine the weighting of decision makers, as seen in the case study, and comprehensively and understandably document the completed make-or-buy decision-making process through the project sheet and the project report. Further testing of the tool involving the parameters defined in the designed framework is addressed during its implementation. The integration of the framework within the proposed tool provides decision makers, practitioners and academics with a practical solution to make decisions in a structured and consistent manner. As observed in the case study, a better understanding of the lessons learned and improvement potentials should be considered for every future MoB decision. Hence, practitioners can learn from past failures by adapting
future requirements and continuously updating the proposed framework and tool. Since the objective of this study is to create a decision model to support strategic sourcing decisions, the research approach presented here is suitable. The research approach will involve a two-stage decision process: the make-or-buy decision and the managerial actions required to implement the decision. Admitting the described findings and contributions, this research faces a number of limitations and so do its outcomes. For instance, a potential limitation of this research stems from the fact that the presented analysis is focused on a set of in-firm make-or-buy decisions from the firm’s perspective. Subsequently, the comparison with other case studies was not evaluated and it would be suggested to compare it with other case studies and other branches and regions.

### 3.7 References


Figure 3-4. Make-or-buy assessment approach

Source: adapted from McIvor (2009).
**Figure 3-5. Key objectives of the tool**

<table>
<thead>
<tr>
<th><strong>A) Criteria for an exclusively insourcing: (internal production or R&amp;D)</strong></th>
<th>preexisting</th>
<th>no preexisting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge protection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technologically core competence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualitative proof of certification bodies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High resource position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High strategic value / Business Strategy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **B) Criteria for an exclusively outsourcing:** |  |  |
| Buy |  |  |
| Knowledge is not available |  |  |
| Technologically non core competence |  |  |
| Low resource bodies |  |  |
| Low strategic value / Business Strategy |  |  |
| High supplier expertise |  |  |

| **C) Criteria for a concurrent sourcing:** |  |  |
| Make & Buy |  |  |
| Multiple source strategy |  |  |
| High level of trust and collaboration |  |  |
| Demand flexibility |  |  |
| Low potential for opportunites |  |  |

| **D) Criteria for a hybrid sourcing:** |  |  |
| Hybrid |  |  |
| Lack of internal resources |  |  |
| High level of trust and collaboration |  |  |
| Long term partnership with supplier |  |  |
| Low potential for opportunites |  |  |
| Skills shortage |  |  |

| **E) Criteria for forming an alliance:** |  |  |
| Alliances |  |  |
| Fast access to new markets |  |  |
| High strategic value / Trade implications |  |  |
| Special synergy with local partner |  |  |
| Sharing risks and possible skills appropriation |  |  |
| Skills shortage on a specific market |  |  |

Source: case study
**Figure 3-6. Required criteria adapted from the framework**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Decision maker / Intern responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strategic value / Business Strategy</strong></td>
<td>CEO</td>
</tr>
<tr>
<td>Profitability</td>
<td>Control</td>
</tr>
<tr>
<td>Sales growth</td>
<td>Sales manager, PL</td>
</tr>
<tr>
<td>Technical differentiation</td>
<td>R&amp;D</td>
</tr>
<tr>
<td>Strategy (multiple/single source strategy) / Second source</td>
<td>CEO, SQA</td>
</tr>
<tr>
<td>Proximity to markets</td>
<td>CEO, PL</td>
</tr>
<tr>
<td>Trade implications</td>
<td>Sales manager</td>
</tr>
<tr>
<td>Demand flexibility</td>
<td>CEO, P</td>
</tr>
<tr>
<td>Macroeconomic and political situation</td>
<td>P</td>
</tr>
<tr>
<td>Core / non core product or services</td>
<td>CEO, PL</td>
</tr>
<tr>
<td>Synergy effects / Cost partnership</td>
<td>P</td>
</tr>
<tr>
<td>Supplier expertise / Contract manufacturers capability</td>
<td>SQA</td>
</tr>
<tr>
<td>Cost reduction (Production vs. Acquisition costs)</td>
<td>Control, PPM, PL, P, SQA</td>
</tr>
<tr>
<td>Competitive advantage</td>
<td>CEO, R&amp;D</td>
</tr>
<tr>
<td>Initial costs</td>
<td>Control, PPM, PL, SQA</td>
</tr>
<tr>
<td>Expected costs / Hidden costs</td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>P, SQA, PPM, PL</td>
</tr>
<tr>
<td>Conversion costs</td>
<td>P</td>
</tr>
<tr>
<td>Contract costs reduction / Commercial evaluation of costs after 3 years</td>
<td>CEO, PPM, PL</td>
</tr>
<tr>
<td>Relationship closeness (internal or external)</td>
<td>SOA, P</td>
</tr>
<tr>
<td>Defects per million / ppm</td>
<td>SOA, P</td>
</tr>
<tr>
<td>Delivery reliability / Project processing in the required time</td>
<td>Manufacturing, PL, SOA</td>
</tr>
<tr>
<td>Manufacturing flexibility</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Overall equipment effectiveness</td>
<td>PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Asset utilization</td>
<td>PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Sustainability punctation</td>
<td>PPM, PL, P, SQA</td>
</tr>
<tr>
<td>Variants reduction</td>
<td>PPM, PL, P, SQA, CEO</td>
</tr>
<tr>
<td><strong>Product supply chain risks / Potential for opportunism</strong></td>
<td>PPM, PL, P, SOA, CEO</td>
</tr>
<tr>
<td>Information asymmetry</td>
<td>SOA, R&amp;D</td>
</tr>
<tr>
<td>CSR (sustainable procurement) ISO 26000</td>
<td>SOA, R&amp;D</td>
</tr>
<tr>
<td>Flexibility / Seasoned</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Strategic risk</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Quality defects</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Delivery delays</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Costs increases</td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Skills appropriation</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Complexity relationship / Contract resolution</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td><strong>Resource position</strong></td>
<td>E, PPM, PL, P, SOA</td>
</tr>
<tr>
<td>Resources / Capabilities available / Process capability</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Skills and know-how available</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Process maturity</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Assets available</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Support systems</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Technology and manufacturing processes</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Technological capability</td>
<td>PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td><strong>Conformance quality</strong></td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>QM assessment</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Audit result (first vs. Second party)</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Certification</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Willingness for contractual agreements (supply chain)</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Supply chain surveillance (subcontractor audit plan)</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
<tr>
<td>Evaluation assessment completed or part of the product/service fit with supply chain</td>
<td>E, PPM, PL, P, SOA, R&amp;D</td>
</tr>
</tbody>
</table>

**Abbreviations**

- **P**: Strategic purchaser
- **SQA**: Supplier quality assurance department
- **R&D**: Research and development department
- **CEO/Chief**: Chief executive officer
- **PPM**: Production planning manager
- **IE**: Industrial engineer
- **PL**: Project leader
- **Others**: e.g. specialist
# 3.8.2 Appendix I: Make-or-buy literature review

## Table 3-4. Make-or-buy literature review

<table>
<thead>
<tr>
<th>Year</th>
<th>Authors</th>
<th>Theory</th>
<th>Method</th>
<th>Key points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>Williamson (1975, 1981, 1985)</td>
<td>Transaction cost economics</td>
<td>Field study</td>
<td>Transaction cost economics addresses these questions: do firms exist? What are the most effective strategies for maximising profits? What should firms make and what should firms buy?</td>
</tr>
<tr>
<td>1978</td>
<td>Pfeffer &amp; Salancik (1978)</td>
<td>Resource dependency theory</td>
<td>Field study</td>
<td>Firms do not have all the resources they need; therefore, to some degree, they depend on their external environment for some resources.</td>
</tr>
<tr>
<td>1978</td>
<td>Miles &amp; Snow (1978); Porter (1985)</td>
<td>Strategic management theories</td>
<td>Field study</td>
<td>Strategy is the determinant of the basic long-term goals of an enterprise, and the adoption of courses of action and the allocation of resources necessary for carrying out these goals.</td>
</tr>
<tr>
<td>1981</td>
<td>Pfeffer (1981, 1982)</td>
<td>Power and politics theories</td>
<td>Field study</td>
<td>Idiosyncratic interests and politics play major roles in organisational decision-making. Power politics theories have been used to study the impact of power and political tactics on outsourcing decisions.</td>
</tr>
<tr>
<td>1983</td>
<td>Rogers (1983)</td>
<td>Innovation theory</td>
<td>Field study</td>
<td>This theory addresses the following question: how do we get individuals or organisations to adopt innovations or to adopt innovations faster? Innovation diffusion theory has been used to study the diffusion of outsourcing.</td>
</tr>
<tr>
<td>1989</td>
<td>Eisenhardt (1989)</td>
<td>Agency theory</td>
<td>Field study</td>
<td>This theory is based on the conceptualisation of firms as a nexus of contracts between principals or stakeholders and agents.</td>
</tr>
<tr>
<td>1990</td>
<td>Doz, Prahalad &amp; Hamel (1990); Inkpen &amp; Beamish (2007)</td>
<td>Alliances</td>
<td>Field study</td>
<td>Alliances are needed to enter new markets, obtain new skills, and share risks and resources. Joint ventures provide low-cost, fast access to new markets by borrowing a partner's already-in-place local infrastructure.</td>
</tr>
<tr>
<td>1990</td>
<td>Fudenberg &amp; Tirole (1990)</td>
<td>Game theory</td>
<td>Field study</td>
<td>Game theory attempts to explain firms' strategic behaviour in particular game situations. The determinant for these decisions is the perception of the expected actions of the other player(s).</td>
</tr>
<tr>
<td>1991</td>
<td>Barney (1991)</td>
<td>Resource-based view</td>
<td>Field study</td>
<td>This theory answers the following question: why do firms in the same industry vary systematically in performance over time?</td>
</tr>
<tr>
<td>1995</td>
<td>Klepper (1995); Kern (1997)</td>
<td>Relationship theories</td>
<td>Field study</td>
<td>This theory focuses on cooperation, interactions, and social and economic exchanges as major factors in inter-organisational relationships. When applied to outsourcing research, they have been used to identify the key dimensions of relationships, including context, and interactions.</td>
</tr>
<tr>
<td>2004</td>
<td>Dibbern et al. (2004)</td>
<td>Strategic theories</td>
<td>Conceptual framework / Field study</td>
<td>This theory focuses on how firms develop and implement strategies to achieve a chosen performance goal.</td>
</tr>
<tr>
<td>2005</td>
<td>Jacobides &amp; Hitt (2005); Gulati, Lawrence &amp; Puranam (2005); Puranam, Gulati &amp; Bhattacharya (2013)</td>
<td>Hybrid sourcing</td>
<td>Conceptual framework / Case study</td>
<td>Jacobides and Hitt (2005) focus on comparative advantage. Hybrid sourcing refers to procurement of the entire volume from a single mode that exhibits mixed governance characteristics. Hybrids are a mode of procurement characterised by a degree of cooperation and coordination that is unusual in market relationships.</td>
</tr>
<tr>
<td>2005</td>
<td>Jacobides &amp; Hitt (2005); Parmiggiani (2007); Puranam, Gulati &amp; Bhattacharya (2013); Park &amp; Ro (2011)</td>
<td>Plural sourcing</td>
<td>Conceptual framework / Field &amp; case study</td>
<td>Plural sourcing refers to the splitting up of total volume being procured across multiple modes simultaneously, each of which may be a pure governance mode. In-house dominance with complementary outsourcing (&quot;major doers&quot;); and outsourcing dominance with complementary in-house activities (&quot;major buyers&quot;). Internal and external sourcing can be synergistic when used concurrently. Complementarities and constraints explain how much firms make-and-buy.</td>
</tr>
<tr>
<td>2009</td>
<td>McVor (2009); Brewer, Ashenbaum and Carter (2013)</td>
<td>TCE–RBV combined theoretical framework</td>
<td>Conceptual framework</td>
<td>The framework, further developed and validated by Brewer, Ashenbaum and Carter (2013), addresses a number of important questions in outsourcing evaluation, mainly: should an organisation maintain and build upon a superior performance position in an activity, or outsource the activity and leverage the capabilities of suppliers? What are the resource implications of investing in an activity to perform it internally and reduce asset specificity?</td>
</tr>
</tbody>
</table>
3.8.3 Appendix II. Questionnaire: interview with industrialists

- Details of the interviewee;
- Areas related to make-or-buy decisions;

1. What of the following performance criterias are taken into account at your organisation during the "Make or Buy" decision process?

<table>
<thead>
<tr>
<th>Less relevant</th>
<th>More relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing flexibility</td>
<td>☐</td>
</tr>
<tr>
<td>Costs reduction</td>
<td>☐</td>
</tr>
<tr>
<td>Quality defects (like defects per million)</td>
<td>☐</td>
</tr>
<tr>
<td>Delivery reliability</td>
<td>☐</td>
</tr>
<tr>
<td>Overall equipment effectiveness</td>
<td>☐</td>
</tr>
<tr>
<td>Risk to core capabilities</td>
<td>☐</td>
</tr>
<tr>
<td>Technical differentiation</td>
<td>☐</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

2. Which of the following criterias for the "make analysis" are more relevant at your organisation?

<table>
<thead>
<tr>
<th>Less relevant</th>
<th>More relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-house process differentiates the product</td>
<td>☐</td>
</tr>
<tr>
<td>Need to &quot;push the technology envelope&quot;</td>
<td>☐</td>
</tr>
<tr>
<td>Few or no alternative sources of supply</td>
<td>☐</td>
</tr>
<tr>
<td>Imperative to couple supply and usage (lead-time) for quick response or quality</td>
<td>☐</td>
</tr>
<tr>
<td>Internally cost-advantaged or at parity, high quality</td>
<td>☐</td>
</tr>
<tr>
<td>Manufacturing investments need required return on invested capital</td>
<td>☐</td>
</tr>
<tr>
<td>Company has strong, definable skill base</td>
<td>☐</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

3. Which reasons for outsourcing are more relevant at your organisation?

<table>
<thead>
<tr>
<th>Less relevant</th>
<th>More relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce costs or revenues related</td>
<td>☐</td>
</tr>
<tr>
<td>Improved service levels</td>
<td>☐</td>
</tr>
<tr>
<td>Provides more flexibility</td>
<td>☐</td>
</tr>
<tr>
<td>Outsourcing non-core business</td>
<td>☐</td>
</tr>
<tr>
<td>Exploits management expertise of contractors</td>
<td>☐</td>
</tr>
<tr>
<td>Outsourcing area was a major problem for the company</td>
<td>☐</td>
</tr>
<tr>
<td>Avoid investment</td>
<td>☐</td>
</tr>
<tr>
<td>Overall improvement of distribution, improved delivery performance</td>
<td>☐</td>
</tr>
<tr>
<td>Other, please specify</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
4. What of the following considerations are taken into account at your organisation during the “Make or Buy” decision process?

<table>
<thead>
<tr>
<th>Eliminate business</th>
<th>Outsource</th>
<th>Form a strategic alliance</th>
<th>Retain business</th>
</tr>
</thead>
<tbody>
<tr>
<td>High strategic importance, core business = High contribution to operational performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High strategic importance, core business = Low contribution to operational performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low strategic importance, non-core business = High contribution to operational performance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low strategic importance, non-core business = Low contribution to operational performance, item not necessary to the firm’s strategy</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Other, please specify

5. Which of the following stages are taken into account during the make or buy decision process at your organisation?

| Planning stage: assess needs, appoint the project team | More relevant |
| Evaluation stage: evaluate implication on company’s strategy | |
| Analysing stage: measure current and future costs and performances | |
| Selecting stage: prepare or deliver request of proposal | |

Other, please specify

6. Which financial elements are relevant at your organisation during the “make-it” decision process?

| Activity costs: labour costs | More relevant |
| Activity costs: overhead costs | |
| Activity costs: raw material costs | |
| Invested capital | |
| Poor information | |

Other, please specify
7. Which financial elements are relevant at your organisation during the "buy-it" decision process?

<table>
<thead>
<tr>
<th>Less relevant</th>
<th>More relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provider’s proposal</td>
<td></td>
</tr>
<tr>
<td>Future pricing in provider’s proposal</td>
<td></td>
</tr>
<tr>
<td>Costs that don’t disappear</td>
<td></td>
</tr>
<tr>
<td>One-time costs</td>
<td></td>
</tr>
<tr>
<td>Ongoing and hidden costs</td>
<td></td>
</tr>
<tr>
<td>Auditing and surveillance costs</td>
<td></td>
</tr>
<tr>
<td>Other, please specify</td>
<td></td>
</tr>
</tbody>
</table>

8. What of the following considerations are taken into account at your organisation for the "Make or Buy" decision tree?

- Need for cost or service improvement?
- Is it a core activity?
- Does it impact core activity?
- Do we have the required resources and skills at the organisation?
- Available supplier expertise and will for a close partnership on the market?
- Calculation fixed & variable costs (Make vs. Buy)
- Evaluate approach between (In-house, Outsource, Form an alliance or eliminate)
- Other, please specify

3.8.4 Appendix III. Survey: case study guide

1. For the past fiscal year, which best describes how you source progressive X-parts (enclosures)?
   1. All done internally (either within your plant or from a division with which your firm shares a common corporate parent)
   2. All purchased from external suppliers
   3. Both done internally and purchased from external suppliers
   (i) If you marked this response, what % of your requirements did you produce internally?
   (Please mark one)
   0%–10%
   26%–49%
   75%–90%
   11%–25%
   50%–74%
   Over 90%
   Do not use this input
Independent variables
Each item included a response scale of 1 to 7, indicating totally true to totally untrue. Items were edited to reflect each different good (e.g., ‘dies’).

Asset specificity
1. The skills needed to create dies are generic and widely available (reversed) (Parmigiani, 2007).
2. Numerous capable die suppliers exist in the market (Walker and Weber, 1984; reversed).
3. Switching die suppliers would be quick and easy to do (Poppo and Zenger, 1998; reversed).

Volume uncertainty
1. Our forecasts for dies are very accurate (Anderson and Weitz, 1986; reversed).
2. There are predictable patterns to our requirements (Anderson and Weitz, 1986; reversed).

Technological uncertainty
1. The processes and skills required to create dies are mature and unlikely to change in the future (Heide and Weiss, 1995; reversed).
2. Major die innovations are very likely within the next few years (Bensaou and Anderson, 1999).
3. Major innovations in how dies are produced are very likely within the next few years (Bensaou and Anderson, 1999).

Performance uncertainty
1. We can easily describe dies to our suppliers through printed/electronic descriptions and/or drawings (reversed) (Parmigiani, 2007).
2. Through a simple inspection, we can predict how well the die will function in our downstream production processes (Bottum, 1992; reversed).
3. We use several forms of inspection and several different metrics to evaluate die quality (Anderson et al., 2000).
4. When there is a problem with a die, we usually can determine its cause (reversed) (Parmigiani, 2007).
5. It is difficult to equitably measure one supplier’s die vs. another supplier’s (Anderson and Schmittlein, 1984).

Firm scope economies
1. By making our own dies, we could reduce our overall production costs of other products (Parmigiani, 2007).
2. We do better utilise our labour and equipment by making dies in addition to our other products (Parmigiani, 2007).
Supplier scope economies
1. By making dies for us, our suppliers can reduce their overall production costs since they can make better use of their labour and equipment (Parmigiani, 2007).

Firm expertise
1. Our manufacturing staff can easily produce dies (Parmigiani, 2007).
3. We have internally produced dies for years (Parmigiani, 2007).
4. The skills used to make dies are closely related to those that we use to make other similar products (Parmigiani, 2007).

Supplier expertise
1. The leading die suppliers have proprietary knowledge that gives them an advantage over other firms (Walker and Weber, 1984).
2. We rely on our suppliers to help us keep up with die technology (Stump and Heide, 1996).
3. There is very little difference between the process we would use to make dies and that used by a supplier (reversed) (Parmigiani, 2007).
4. As compared to suppliers, our internal production of dies would be higher in price (Anderson, 1985; reversed).
5. As compared to our suppliers, our internal production of dies would be lower in quality (Anderson, 1985; reversed).

Theories
1. We build up optimal contractual relationships with our suppliers based on incentives and other control mechanisms (Agency theories) (reversed).
2. We faced issues (problems) with suppliers and made rational and intelligent decisions to maximise our profit (Game) (reversed).
3. We outsource products and services when our internal resources and capabilities are weak (RBV).
4. We resolve make-or-buy decisions based on cost factors, whenever the potential for opportunism is low (TCE).
5. We acquire innovation from suppliers by combining make-and-buy decisions (Innovation).
6. We adopt innovation from suppliers by outsourcing services and processes (Innovation) (reversed).
SUSTAINABLE SUPPLIER EVALUATION PRACTICES ACROSS THE SUPPLY CHAIN: A MULTIPLE CASE STUDY
4. Sustainable supplier evaluation practices across the supply chain: a multiple case study (Art. 3)

SUSTAINABLE SUPPLIER EVALUATION PRACTICES ACROSS THE SUPPLY CHAIN

PRÁCTICAS DE EVALUACIÓN DE PROVEEDORES SOSTENIBLES A TRAVÉS DE LA CADENA DE SUMINISTRO

Abstract
In the last decade, academic research on sustainability has evolved rapidly in the supply chain literature, so there has been scant opportunity thus far for the research community to complete a global assessment of sustainable supplier evaluation activities. This paper seeks to address this need by exploring sustainable supplier evaluation practices and developing a multiple criteria decision-making (MCDM) model based on the combination of the triple bottom line (TBL) and the TOPSIS methodologies to help professionals evaluate external providers all along the supply chain. In order to create a robust framework for sustainable supplier evaluation, two case studies were selected and compared. Both case studies were also useful to refine the framework and illustrate how to use it. Identifying best practices for integrating corporate social responsibility involves the evaluation of external providers’ certification according to the ISO 9001, ISO 14001, ISO 50001 and ISO 45001 standards. Accepting the firm’s code of conduct and monitoring it throughout the whole supply chain phases are relevant factors to be considered in order to ensure procurement sustainability. The proposed model can be used as a guideline to provide managers, practitioners and academics with a practical solution to resolve external provider evaluation decisions and determine the ranking order of preferred external providers in a more structured and consistent manner.

Resumen
En la última década, la investigación académica sobre sostenibilidad ha evolucionado rápidamente en la literatura sobre la cadena de suministro, por lo que los investigadores han tenido pocas oportunidades para completar una evaluación global de las actividades de evaluación de proveedores sostenibles. Este trabajo aborda esta necesidad explorando las prácticas para la evaluación de proveedores sostenible y desarrollando un modelo de toma de decisiones.

The author would like both to express his gratitude to the editor and to the anonymous reviewers for all their helpful suggestions.
de decisiones de criterios múltiples (MCDM) basado en la combinación de la línea de base triple (TBL) y las metodologías TOPSIS para ayudar a los gerentes a evaluar proveedores externos a lo largo de la cadena de suministro. Para crear un esquema sólido, se seleccionaron y compararon dos casos de estudio. Ambos estudios de caso también fueron útiles para refinar el marco e ilustrar cómo usarlo. La identificación de las mejores prácticas para integrar la responsabilidad social corporativa implica la evaluación de la certificación de proveedores externos de acuerdo con las normativas ISO 9001, ISO 14001, ISO 50001 e ISO 45001. Aceptar el código de conducta de la empresa y monitorearlo a lo largo de todas las fases de la cadena de suministro son factores relevantes que deben considerarse para garantizar la sostenibilidad de las adquisiciones. El modelo propuesto puede usarse como una guía para proporcionar a los gerentes, profesionales y académicos una solución práctica para tomar decisiones de evaluación de proveedores externos y determinar el orden de clasificación de los proveedores externos preferidos de una manera más estructurada y consistente.

**Keywords:** Supplier evaluation, decision-making, sustainable outsourcing, sustainable supply chain, CSR (Corporate Social Responsibility)

**Palabras Clave:** Evaluación de proveedores, toma de decisiones, subcontratación sostenible, cadena de suministro sostenible, RSE (Responsabilidad Social Corporativa)

<table>
<thead>
<tr>
<th>4.1 Introduction</th>
</tr>
</thead>
</table>
| There is a growing audience for sustainable supplier evaluation research, as the importance of analytical expertise, general management backgrounds, and deep knowledge in a particular purchasing category becomes widespread. The ISO 26000 standard released in 2010 provides guidance on understanding, implementing and continuously improving the social responsibility of organizations, which is understood as the impact of firms’ actions on society and environment. ISO 26000 defines seven principles of social responsibility (ISO 26000, 2010):
| • Accountability: being answerable for decisions and activities and their impact on society, the economy and the environment.
| • Transparency: being open about decisions and activities that have an impact on society and the environment. |
• Ethical behavior: in accordance with accepted principles of right or good conduct.
• Respect for stakeholders’ interests: respecting, considering and responding to the interests of stakeholders.
• Respect for the rule of law: mandatory.
• Respect for international norms of behavior.
• Respect for human rights.

How can firms evaluate their suppliers’ effectiveness including sustainable criteria? The interest of researchers and practitioners about the literature favoring “buy” decisions and supplier evaluation has increased in the last decades. Supply selection and evaluation decisions have been addressed from multiple viewpoints. Due to the importance of sustainability in the supply chain systems, there is a need to update the sustainable sourcing literature as part of the supplier development process to help and guide practitioners to evaluate sustainability criteria within the supply chain. The purpose of this study is to solve this need by designing a sustainable external provider evaluation framework by further developing the triple bottom line (TBL) concept, integrating subcategories, and presenting a multi-criteria approach. The rest of the paper is structured as follows. First, Section 4.2 reviews the literature on supplier evaluation processes with focus on sustainable supply chain practices and develops the supplier evaluation framework. Second, the firms involved in the multiple case study are presented in Section 4.3. Then, Section 4.4 described the best practices for the implementation of the proposed framework integrated in the model (pairwise comparison and decision matrix) for real case studies. Findings from the multiple case study and the validation of the framework are explained in Section 4.5. Finally, discussions and conclusions are outlined in Section 4.6.

### 4.2 Literature review

#### 4.2.1 Literature review on the supplier evaluation process

Chen, Lin and Huang (2006) presented a fuzzy decision-making approach to deal with the supplier selection and evaluation problem in supply chain systems. They proposed the TOPSIS concept as a hierarchy multiple criteria decision-making (MCDM) model to solve the external provider selection problem. Sevkli et al. (2007) implemented the data envelopment
analytic hierarchy process (DEAHP) methodology for supplier selection and evaluation in a case study at Beko in Turkey. They highlighted the consistency of this hybrid method as compared to the AHP methodology alone. However, they did not take into account the demands of various stakeholders to comply with environmental legislations and social responsibilities. Whereas Gencer and Gürpınar (2007) developed a model based on the analytic network process (ANP) to systematize supplier selection and evaluation practices, Tsai, Huang and Wang (2008) combined the ANP and TOPSIS concepts for evaluating the performance of property-liability firms. TOPSIS is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon (1981), with further developments by Yoon (1987) and Hwang, Lai and Liu (1993). TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution (Assari, Mahesh and Assari, 2012). Furthermore, Boran et al. (2009) proposed an intuitionistic fuzzy set for finding the best option of all the feasible alternatives.

In contrast, Öztürk and Özçelik (2014) examined how to identify the best supplier by means of sustainability principles for supplier selection and evaluation operations. They presented a multi-criteria analysis and solution approach based on the TOPSIS method and including the sustainable criteria defined in the Triple Bottom Line (TBL) method. Also, the TBL (profit, people and planet) approach was chosen by Sarkis and Dhavale (2015) to create a Bayesian framework for evaluating external providers. TBL is a method for measuring sustainability performance developed by Elkington (1994) and perfected by Jackson, Boswell and Davis (2011). TBL is an approach for management and performance evaluation that emphasizes the importance of economic, environmental, and social performance. Although Öztürk and Özçelik’s (2014) approach employed a well-known and useful methodology like the TOPSIS concept, they failed to consider strategic, resource and quality conformance criteria within their approach. Furthermore, Chaharsooghi and Ashrafi (2014) proposed a sustainable supplier selection and evaluation model combining an improved version of the TBL methodology with the neofuzzy TOPSIS methodology. Hence, the employment of the TBL and TOPSIS methodologies to address sustainable supplier evaluation decisions is identified.

4.2.2 Literature approach on the supplier evaluation framework

A supplier evaluation framework is proposed in this study after conducting a literature review on supplier evaluation frameworks. As has been done in the past by other researchers this
thesis summarizes the most relevant external provider evaluation criteria into main clusters. In addition to the theories categorized by Dibbern et al. (2004), theories and insights concerning sustainable procurement, combinations of the transaction cost economics (TCE) and resource-based view (RBV) theories and supplier evaluation frameworks are identified. In essence, the TBL theory and methodology for the measurement of sustainability performance was taken into account. As observed from the literature, this theory has been employed by both academics and industrialists to evaluate the grade of sustainability on external providers’ selection and evaluation practices (Elkington, 1994; Öztürk and Özçelik, 2014).

After the interview with EcoVadis, a renowned service provider for supplier sustainability ratings, this research realized that the TBL concept is also employed in the industry for assessing the sustainability risks involved (EcoVadis, 2018). Due to the increased relevance of sustainable procurement in the last decade, this thesis has adapted the hierarchical structure of sustainable supplier evaluation’s concept of Öztürk and Özçelik (2014) of three streams, namely: (1) economic value; (2) environmental position; and (3) social responsibility. Every stream or main cluster is subcategorized into the main TOP4 sub-criteria for the corresponding evaluation. The structure of the framework with the definition of these main clusters are implemented into the pairwise comparison sheet.

The first stream (economic) analyzes external provider evaluation from an economic perspective, which is broken down into four subcategories, mainly: (1) costs; (2) quality; (3) lead time and on-time delivery; and (4) technological capability.

(1) What should firms buy for maximizing profits while keeping a low risk for opportunism?

This subcategory approaches sustainable procurement taking into account opportunism from a cost perspective and a risk mindset, based mainly on the TCE theory (Coase 1937; Williamson 1975, 1981, 1985). The main theoretical argument of this theory is concerned with the fact the conditions of the transaction would lead to its internal or external governance. It has two fundamental behavioral assumptions: (1) bounded rationality (Simon 1957) and (2) opportunism. This risk of opportunism is a factor addressed in the game (Fudenberg and Tirole, 1990) and agency (Eisenhardt, 1989) theories, intended to safeguard firms from possible risks. When applied to the external provider evaluation process, it posits that firms need to consider second source alternatives for ensuring an emergency plan B, thus gaining a better negotiation position with providers. The potential for opportunism evaluation considers the following criteria: (1) quality defects; (2) delivery delays; (3) costs increase; (4) skills appropriation; and (5) complexity
relationship / conflict resolution. The subcategory definition was provided in order to simplify the terminology for practitioners. The conflict resolution criterion, among others, was also supported by Chen, Lin and Huang (2006) in their supplier selection approach.

(2) The second subcategory addresses external provider evaluation from a quality conformance perspective. As the importance of quality has much increased in the last years, the thesis has defined a mainly quality-focused cluster based on other supplier evaluation approaches (Chen, Lin and Huang, 2006). Quality has received so much attention that there are quality certifications for firms and practitioners. In recent years, firms’ processes are usually controlled by quality managers and documented in a quality management handbook (QMH). The following criteria within this subcategory are considered: (1) QM assessment; (2) audit result; (3) certification; (4) willingness for contractual agreements (CA); (5) supply chain monitoring; (6) assessment of whether a completed product, service, or part of it, fits the supply chain; and (7) traceability.

(3) Lead time and on-time delivery is a strategic criterion and key performance indicator (KPI) monitored by many firms, as a delivery delay by an external provider can cause a manufacturing planning delay followed by a customer order delay. One of a firm’s targets is to deliver customer orders on time.

(4) The fourth subcategory examines dichotomous external provider evaluation from a resource viewpoint (Barney, 1991; Penrose, 1959; Pfeffer and Salancik, 1978; Thompson, 1967). First, the resource perspective plays an important role, especially in the RBV (Barney, 1991) and the resource dependency theory (Pfeffer and Salancik, 1978). Chen, Lin and Huang (2006) introduced the main technological capability criteria to be considered in supplier evaluation frameworks. Thus, after introducing the main findings from the abovementioned literature, the following criteria within this subcategory are taking into account: (1) process capability available; (2) skills and know-how available; (3) process maturity; (4) assets available; (5) support systems; and (6) technological and manufacturing capability. The subcategory definition was provided in order to simplify the terminology for practitioners.

The second stream (environmental) addresses the dichotomous external provider evaluation decision from an environmental viewpoint which is split into four subcategories, mainly: (1)
pollution control; (2) resource consumption (ISO 50001 - Energy Management); (3) green product and eco-design (REACH/RoHS and conflict minerals reporting template (CMRT)); and (4) environmental management system (ISO 14001). Using energy efficiently helps organizations save money and resources and tackle climate change. According to Öztürk and Özçelik (2014), firms started to analyze their supply chains to enhance their overall sustainable supply chain management (SSCM) profile and meet the demands of stakeholders and customers to comply with environmental legislation. SSCM refers to the integration of environmental and social issues into supply chain management (SCM) in order to improve firms’ environmental, social and economic performance (Gimenez, Sierra and Rodon, 2012; Öztürk and Özçelik, 2014). The sustainable supplier evaluation process is a central concept of sustainable supply chain management.

The third stream (social) delves into external provider evaluation from a social viewpoint. For instance, social stream breaks down into: (1) health and safety practices (BS OHSAS 18001/ISO 45001 - Occupational Health & Safety); (2) social responsibility; (3) education infrastructure; and (4) employment practices. The second and third streams deal with external provider evaluation from an environmental and social responsibility perspective taking into account suppliers’ CSR (Corporate Social Responsibility) score and suppliers’ code of conduct (CoC). Over the last few years, following the release of the ISO 26000 guidelines, more attention has been paid to sustainable procurement, and firms have started to consider environmental and social criteria, besides economic ones, to evaluate their external providers. Supply chain management sustainability has been explored in recent years by some researchers who identify the need to develop a framework for the implementation of social responsibility in the external provider evaluation process (Chaharsooghi and Ashrafi, 2014). In contrast to the past reviewed approaches, the proposed approach can be adapted to specific firm’s decision makers’ hierarchy, by assessing the relevance of the decision makers involved.

On the other hand, supplier requirements in terms of economic, environmental and social differ from specific manufacturing activities and material groups. Thus, the defined ideal punctuation can be set and adapted into the decision matrix for single supplier evaluations.
4.3 Data collection methods

In order to create a robust framework and examine the practicality and effectiveness of the proposed sustainable supplier evaluation approach, two case studies were selected and compared. The main criterion for the selection of the cases was the convenience of the author with both firms. One supplier is located in Europe and the other is overseas, in China. The firm A is the tier 1 and the firm B is the tier 2 of an end-German-customer. Both suppliers were visited and interviewed using the proposed framework. Several issues required to be addressed. First, a better understanding of how sustainable supplier evaluations are understood in China and Europe is required. Second, a better understanding of the lessons learned and improvement potentials collected from the interviews with decision makers from both firms had to be analyzed and prioritized. Third, a clear understanding of the interrelation between the firm, third parties and the triggers, factors, intercultural communication and possible outcomes of supplier evaluation approaches should be identified. The interviews, their design, the analysis of the transcripts and how the findings were incorporated into the framework are described here. An analysis of the recent external provider evaluation literature was performed and served as the basis for preparing and designing the interviews. Semi-structured interviews with middle-level managers from both firms were conducted. An interview questionnaire with a preliminary framework was designed based on the literature and served as an interview guide. Interview sessions took slots of over one hour and mainly covered the following topics:

- areas related to external provider evaluation
- criteria to be considered during sustainable external provider evaluation
- functions involved in the sustainable external provider evaluation process
- strengths and weaknesses of current and past decisions
- lessons learned and suggestions from current and past decisions
- stages taken into account during the external provider evaluation process

4.3.1 Case study: Firm A

To undertake the first case study, information on how previous external provider evaluation decisions had been approached, is collected. The information was obtained from an experienced printed circuit board assembly (PCBA) and electronics manufacturing services (EMS) provider. The firm, based in Slovakia and exporting mainly to Germany and the
European market, has been active since 1995. It has approximately 200 employees and a €11 million revenue (key figures from 2017). The firm is ISO 9001 (Manufacturing), ISO/TS 16949 (Automotive), ISO 18001 (Occupational Health and Safety) and ISO 14001 (Environment) certified and also complies with RoHS, REACH and conflict minerals directives. Additionally, the firm has an intern code of conduct (CoC) which contains the main social criteria defined in ISO 26000. The scope of the firm management system complies with the ISO 80079-34 and ISO 13485 standards. Yearly environmental and social targets are defined, documented and monitored. The firm allegedly has a green energy certificate from Slovenské elektrárne, which is the largest power generating company and the biggest investor in Slovakia. Firm facility environmental control system is ISO 14001-certified.

4.3.2 Case study: Firm B

The second case study was based on the information on previous external provider evaluation decisions obtained from a leading manufacturer of printed circuit boards (PCB). The firm is a global player based in Shenzhen, China with three manufacturing facilities, eight sales tech support offices and 80 sales representatives. The firm has approximately 2,100 employees and a $152 million revenue (key figures from 2017), with a revenue forecast of $198 million for 2018. The case study was undertaken in order to document the external provider evaluation process for previous and ongoing decisions. The firm is ISO 9001 (Manufacturing), ISO/TS 16949 (Automotive), ISO 13485 (Medical) and ISO 14001 (Environment) certified and also complies with the U.S. Dodd-Frank Act for conflict minerals. Additionally, the firm has an intern and external provider code of conduct (CoC) which contains the main social criteria defined in ISO 26000. The visited headquarter in China complies with RoHS, REACH and PFOS directives and is ISO/TS 14067 (Product Carbon Footprint) certified.

4.4 Best practices for the implementation of the framework

In order to explain the practical implementation of the framework into the model (pairwise comparison and decision matrix), the interdependencies between elements and the pairwise comparison and to collect best practices for sustainable supplier evaluation, the model is put into the practice using a multiple case study. When choosing decision makers (DM) for the interviews at the multiple case study, those decision makers within the procurement process of firm A and B who are most willing to explain the decisions made at their workplace are
selected. Those decision makers who have a business relationship with one the author, who is involved in the supplier evaluation process, are categorized into three levels: (DM1) who are represented by managers and strategic purchasers; (DM2) Research & Development, industrial engineers and specialists; and (DM3) for quality assurance and quality representatives. The weight of decision maker levels is set as follows: DM1 is 0.406; DM2 is 0.238; and DM3 is 0.356 so that the total of the weighting is 1 (Boran et al., 2009).

Compared to the previous alternative approaches reviewed, one of the main novelty of the proposed approach is the standardization of fix decision makers’ weights for all supplier evaluation decisions according to their function at the firm defined in the firm’s organigram. This contribution was preferred by practitioners in order to simplify the tool. Decision makers of both firms were asked to respond to a series of pairwise comparisons where two criteria elements at a time were compared in terms of how they contribute to their corresponding upper level criterion.

Figure 4-1. Pairwise comparison Firm B

Source: own source.
The consistency of each pairwise comparison was also checked in this step. The relative importance values are determined on a scale of 0 to 2, where a score of 0 represents less importance than the other criterion, a score of 1 indicates equal importance between the two elements, and a score of 2 indicates the maximum importance of one element (row component in the matrix) compared to the other one (column component in the matrix) following Figure 4-1 (Firm B). The weightings of each criterion are then determined and adapted in the pairwise comparison. For example, the assessment by the pairwise comparison between Quality (Eco2) and environmental is 1, which means that Quality is equally important than environmental. Economic cluster is weighted with 8 calculated from the division between 2.5 and the maximum value from the “Total” column, multiplied by ten so that the (weight(factor) for economic is drawn in Eq. W:

\[
\text{Weight(factor)} = \text{INT} \left( \frac{2.5}{\text{MAX}(2.5;3;3)} \right) \times 10 = 8
\]

On the other case study, three decision makers from the management, engineering and production areas assessed the scores determined on a scale of 0 to 2 as described above, but separately. For instance, the social cluster of Firm A is weighted with 9, 10 and 8 by DM1, DM2 and DM3 respectively. These weighting factors results are added into the social cluster’s weighting factor field of the decision matrix of the Firm A. Results of the pairwise comparison are illustrated in Figure 4-2.
Figure 4-2. Pairwise comparison of Firm A (DM1, DM2, DM3)

Source: case study - Firm A.
The supermatrix is built using the underlying logic of TOPSIS, which involves defining the ideal solution and the negative ideal solution. The ideal solution is the solution that maximizes the benefit criteria and minimizes the cost criteria; whereas the negative ideal solution maximizes the cost criteria and minimizes the benefit criteria. The optimal alternative is the one which is closest to the ideal solution and farthest from the negative ideal solution. The ranking of alternatives in TOPSIS is based on “the relative similarity to the ideal solution”, which avoids the situation of having the same similarity to both the ideal and the negative ideal solution (Deng, Yeh and Willis, 2000). To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix, known as a supermatrix. As a result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system.

The framework detailed above provides a comprehensive account of relevant areas, factors, possible triggers and outcomes to be considered in supplier evaluation decisions. However, it is necessary to weight and rate these areas and factors for practical cases. In addition to the one-page graphical illustration, a tool with a decision matrix was developed based on the guidelines of the pairwise comparison technique (Thurstone, 1927) and the technique for order preference by similarity to ideal solution (TOPSIS) method. The pairwise comparison technique is widely employed to handle subjective and objective judgments in multi-criteria decision-making, especially as a method to determine the weighting of criteria (Kou, Ergu and Shang, 2014). The TOPSIS method has been analyzed using multi-criteria models for complex decisions and multiple attribute models for the most preferable choice.

Based on the supermatrix, each condition is evaluated on a scale of 1 to 5, where a score of 1 means that the condition does not meet the requirements, a score of 2 indicates that the requirements are only partly met, a score of 3 indicates that the requirements are almost completely fulfilled, a score of 4 means that the requirements are fully met and a score of 5 indicates that the condition reaches a level of excellence. The weightings of each criterion are then determined and adapted in the supermatrix. A better understanding of the framework’s implementation into the supermatrix is illustrated from a multiple case study in Figure 4-3 by comparing the assessment of both case studies. Whereas the Firm B assessed the weighting of the main cluster using the pairwise comparison tool together in a consensual workshop, decision makers from the Firm A assessed the weighting of criteria individually. Admittedly,
the environmental cluster is the most relevant for both firms which is weighted with a factor of 9.3 and 10 for Firm A (PCBA) and Firm B (PCB) respectively. While the ideal expected punctuation set at the firm for suppliers belonging to the PCB material group’s category is defined to five for the three main clusters, the PCBA’s ideal punctuation is set to 3, 3.1 and 3.3 for the economic, environmental and social clusters respectively. Thus, Firm A and Firm B are evaluated with 88% and 83% degree of completion respectively from a maximum punctuation of 100%.

Figure 4-3. Decision matrix assessment: Firm A vs. Firm B

A supermatrix can be employed to determine the effects of interdependence between the elements of the system. It is a partitioned matrix, where the weighted values are obtained from the pairwise comparison matrix. The supermatrix is calculated according to the procedure defined in the research by Temuçin et al. (2013), comprising the following steps:

**Step A. Creating decision (A) and weighting (W) matrices:**
At the beginning, the decision matrix, which consists of three components, has to be determined. These components are alternatives defined by a1, a2, ..., ai, am; criteria defined by c1, c2, ..., cj, cn; and performance values defined by aij (i = 1, 2, ..., m) (j = 1, 2, ..., n).
Additionally, the weighting values for each criterion, \( w_1, w_2, \ldots, w_j, w_n \), are taken from the previous pairwise matrix result.

**Step B.** Creating the normalized decision matrix (X). The normalized decision matrix can be created according to Eq. (1) to make the data dimensionless.

\[
\text{Eq. (1)} \quad x_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{n} a_{ik}^2}}
\]

**Step C.** Creating the weighted normalized decision matrix. The weighted normalized decision matrix can be created according to Eq. (2).

\[
\text{Eq. (2)} \quad Y_{ij} = Y_{ij}, W_j
\]

**Step D.** Determining positive and negative ideal solutions considering the three main clusters and the rating scale (from 1 to 5). Positive and negative ideal solutions can be determined with Eqs. (3) and (4).

\[
\text{Eq. (3)} \quad P_j^+ (\max P_{ij} ; c_1 - c_5)
\]

\[
\text{Eq. (4)} \quad P_j^- (\min P_{ij} ; c_1 - c_5)
\]

**Step E.** Calculating separation measures. The positive and negative ideal separation measures, \( S_i^+ \) and \( S_i^- \) respectively, can be calculated with Eqs. (5) and (6) as proposed by Temuçin et al. (2013).

\[
\text{Eq. (5)} \quad S_i^+ = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_j^+)^2}
\]

\[
\text{Eq. (6)} \quad S_i^- = \sqrt{\sum_{j=1}^{n} (y_{ij} - y_j^-)^2}
\]

**Step F.** Calculating the relative closeness to the ideal solution. The relative closeness to the ideal solution, \( C_i^* \), for each alternative can be calculated according to Eq. (7).

\[
\text{Eq. (7)} \quad C_i^* = \frac{S_i^-}{S_i^+ + S_i^-}
\]

where \( 0 \leq C_i^* \leq 1 \) and \( i = (1, 2, 3, \ldots) \).
**Step G.** Ranking alternatives in preference order. Finally, the alternative with the highest $C_i^*$ represents the best choice. External providers from the same material group can be ranked with the supermatrix. In this step the decision and the alternatives are determined. The alternatives are selected from the successful ones in their field, $C_i^*$ $C_1 > C_2 > C_3 > C_4 > C_5$. The details of the scenarios are presented and second source options should be evaluated and, if appropriate, a multiple source strategy addressed according to the results. Results with a score within 100%–80% are highly recommended; those with a score within 80%–60% are recommended; those with a score within 60%–40% are recommended but involve some risk; for those with a score within 40%–20% the assessment status is recommended with high risk; and results with a score lower than 20% are not recommended.

4.5 Findings from the multiple case study

Any organization assessing a decision should critically examine and state what it wants to achieve through outsourcing. Both case studies were carried out using evidences from multiple sources, such as non-disclosure agreements (NDA), confidential disclosure agreements (CDA), supplier self-disclosure reports, supplier evaluation assessments, quality assurance agreements (QAA), supplier audit reports, delivery contracts, final reports and project plans, with a view to validity and reliability (Yin, 1994 and 2018). Both case studies were also useful to refine the framework and illustrate how to use this framework.

The framework aims to provide a graphical representation of why and how supplier evaluation decisions are made. The framework is designed according to the three research streams (1) economic; (2) environmental; and (3) social; identified in the literature and confirmed through the findings analyzed in the case studies. A number of factors were suggested and incorporated into the framework as sub-criteria.

External forces on which a firm’s influence is minimal usually activate triggers and factors for the supplier evaluation analysis. For instance, the availability of a high number of qualified and expert external providers can allow the firm to focus on its core competence activities and outsource non-core activities. Thus, the firm can take advantage of external providers’ expertise and a contractual cost reduction thanks to the economy of scale. In contrast to the existing supplier evaluation processes, the presented framework provides a practical and target-oriented overview where decision makers can evaluate external providers categorizing
them into different material groups. This framework also appears to meet Miles and Huberman’s (1984) requirements for building a comprehensive framework. Interestingly, the framework provides a big picture for academics and practitioners to locate the supplier evaluation process as part of strategic procurement activities. The supplier evaluation process should be documented and decision makers trained regularly in order to ensure the efficiency of the process.

4.5.1 An illustration of the framework using a case study

This section shows how this framework and its content are in line with the considerations of the multiple case study discussed. The triggers, the external elements which activate the triggers, the areas and factors and the final outcome in each case are discussed in this section. Thus, the framework with the results of both supplier evaluation processes is illustrated in this section.

**Firm and environment**

The sustainable supplier evaluation process was related to the manufacturing of PCBs by Firm B and the PCB assembly involving electronic planar transformers by Firm A. Interestingly, Firm B sources PCBs to Firm A and both firms are an example of a successful overseas relationship within the supply chain.

**Triggers**

From the analysis of the case, it was clear that the main trigger for the supplier evaluation process was the new product introduction and the need to process the project in the required time. The current high demand of electronic manufacturing parts in the global market and the allocation of parts by suppliers makes difficult to find electronic manufacturing services (EMS) providers with enough resources, skills and expertise to accept this order. On the other hand, the Chinese firm has prototyping and customer support in Europe to closely support its customers and intermediate with the managers and the production in China. As a result of this, a multidisciplinary team was set up to conduct the supplier evaluation analysis.

**Considerations for the sustainable supplier evaluation process**

*Economic considerations.* These parts assessed for Firm A provide a clear competitive advantage and have a relatively high strategic value to the end customer because of their technical differentiation against competitors. This was a relevant factor, together with the
close partnership involved, supplier profitability, multiple sourcing strategy, and demand flexibility. Whereas the lack of available contract manufacturers in the market with advanced technology and expertise in similar industries is currently an issue, the Slovakia-based firm has available resources to process and deliver customer projects within the expected time. Special test adapters and tooling would be required to perform the in-circuit and functional tests at the supplier’s site. On the other hand, the Firm B is extending one of its PCB manufacturing sites in China so that its capacity will be increased and new customer orders can be accepted. The need to deliver this new product to the firm’s end customers on time is a clear advantage for the firm against its competitors. In order to conduct an in-depth supplier evaluation, an on-site supplier audit was performed by both suppliers on 13 March and 15 June 2018 in Slovakia and China respectively. Due to the special certification and technical requirements of the parts, a support system and team would be required.

Contract cost reduction was a relevant criterion, but a high delivery performance was fundamental for the assessment. The China-based firm obtained a high score in the assessment of its technology and manufacturing processes; moreover, its cost advantage and high resource position would help the firm complete the project within the expected time. The Slovakian supplier got a higher sustainability rating, which was consistent with both suppliers’ certification and the on-site audit. Defining key performance indicators to monitor the process is essential to evaluate the outcome decision. Contract cost reduction indicators, delivery and quality performance figures and asset utilization were taken into account.

The level of quality, the delivery performance and the flexibility of both firms to deliver the project within the required time are excellent. Information asymmetry is a significant issue for both firms, as this research is based on a project where the final product is delivered to a German customer.

Other factors considered included the risk for an increase in quality defects, purchasing costs, delivery delays and a complex relationship with both external providers. Additionally, monitoring and auditing costs would be required to support the external provider until the process had reached maturity and stability at its site. A key selling point for both suppliers is that, in both firms, their customer support service is located in Germany, close to the end customer. After undertaking an audit on both sites, it’s verified that both firms are ISO 9001 and ISO/TS 16949 certified. Besides, the Chinese firm was ISO 13485 certified (requirements for manufacturers of medical devices). The Slovakian firm was more willing to enter into
contractual agreements than the Chinese one, but the Chinese supplier provided a more reliable supply chain monitoring plan. The investment in technological assets by both suppliers improves the final product and decrease failures and errors in the supply chain.

Environmental considerations. Both external providers have a valid and certified environmental management system which complies with the ISO 14001 requirements. The aim of the end customer is to select a supplier with a high resource position, high profitability, high CSR reputation and low potential for opportunism, with a preference for centrally arranging the completed processes, services and having qualitative proof for certification bodies. The conflict minerals reporting template (CMRT) report, which is internationally standardized, is required as proof of conformity in connection with conflict minerals. One practical example of a CMRT report from CFSI is illustrated in Figure 4-4. Firm A has established a conflict mineral sourcing policy and its suppliers are required to be DRC conflict-free. “DRC Conflict-Free” is defined to mean products that do not contain conflict minerals or their derivatives determined to be directly or indirectly financing or benefiting armed groups in the Democratic Republic of Congo (DRC) or adjoining country (Sudan, Uganda, Rwanda, Burundi, United Republic of Tanzania, Zambia, Angola, Congo, Central African Republic). The firm is committed to support and subscribe to the use of DRC Conflict-Free Minerals which include gold (Au), tantalum (Ta), tungsten (W) and tin (Sn). Conflict minerals declaration statements are collected and corrective actions are assessed if appropriate. Admittedly, due diligence information received is reviewed. This declaration sheet of Firm A is intended to identify smelters and confirm if any 3TG, like tantalum, tin and tungsten, is intentionally added or used in the products or in the production process. An example of the declaration sheet of Firm A is as follows:

1. Is any 3TG intentionally added or used in the products or in the production process?
   Tin: HAL and chemical tin for PCB, solder paste, tin, wire tin - Pb, Pb-Free, electro-components
   Gold: PCB pads

2. Does any 3TG remain in the product?
   Tantalum and tungsten: no
   Tin and gold: yes

3. Do any of the smelters in your supply chain source the 3TG from the covered
countries?
Tin: yes
Gold: unknown

4. What percentage of relevant suppliers has provided a response to your supply chain survey?
Tin: greater than 75%
Gold: none
### Social considerations.

As part of the sustainable supplier evaluation, both external providers are evaluated in terms of social, ethical and sustainable supply chain aspects. Both suppliers
have established an internal code of conduct (CoC). Whereas the Chinese firm has a specific CoC for suppliers and the Slovakian firm does not, the work conditions in China lag far behind those in Europe. After the interview with some employees at the Chinese firm, it’s realized that they work 12-hours per shift and, when they start working, they have five holidays per year, which increase to ten holidays after ten years of employment at the firm. On the other hand, the firm offers employees dormitories close to the firm without charging extra costs for living, only costs for electricity, etc. This social benefit, the sports activities available and a canteen in the firm are very welcome by employees. Admittedly, many Chinese firms, like Firm B, were in the past ruled by the government, and this influence is still intrinsically seen in the firm. While the Slovakian firm has received an OHSAS 18001 - Occupational Health & Safety certification, Firm B does not have such a certification. Neither of these firms meets the CSR evaluation criterion, but the Slovakian firm has a quality management system (QMS) which takes into account yearly social targets. Hence, this crucial criterion is the most relevant one in the supplier evaluation.

Hereafter, the weighting of the defined clusters (economic, environmental and social) in the assessment by Firm A was evaluated by three decision makers from the management, engineering and production areas as an example for the operationalization of the framework. The weightings of each criterion are then determined and adapted in the pairwise comparison. Next, the normalized decision matrix for the three clusters was constructed using Eq. (1). Then, the weighted normalized decision matrix was constructed using the Eq. (2). In the following step, the positive and negative ideal solutions considering the three criteria and the rating scale (from 1 to 5) were determined using Eqs. (3) and (4) and the positive and negative ideal separation measures, $S^+_i$ and $S^-_i$ were calculated using Eqs. (5) and (6) respectively. These three decision makers used the defined variables to assess the importance of criteria and evaluate the ratings of candidates with respect to each criterion. The computational procedure of the proposed method and the closeness coefficient of each firm to the ideal solution calculated according to Eq. (7). Finally, even though both results are within the 80%-100% range, and supplier evaluation is therefore highly recommended in both cases, they cannot be properly compared because the firms belong to different material groups and therefore have different expected ideal solutions. Firm A and Firm B belong to the material groups “PCBA” and “PCB” respectively. It can be perceived that sustainable criteria play an important role in sustainable supplier evaluation. The last scenarios demonstrate the applicability and adaptability of the proposed model in the sustainable supplier evaluation.
process. Hence, a different definition of the ideal alternative, in terms of sustainability, would lead to changes in the supplier evaluation ranking.

4.6 Discussion and conclusions

With a view to transfer the knowledge to future generations, firms should describe the process in depth and update it accordingly. Therefore, new employees or decision makers can be trained and they can enhance the process standardization. One of the issues observed during the audit at the Firm B is the language communication barrier found between the end customer’s specification in German language, the tier one translation in Slovakian and the tier two translation in Chinese. Thus, Firm B (tier two) misunderstood a product’s specification because of a translation failure. During the on-site audit, the Chinese firm was encouraged to actively contact its customer for any doubts or questions during the manufacturing or contractual review process. Also, the Chinese firm was recommended to write its specifications as clear as possible and clarify them before processing the customer order. Control plans, failure mode effects analysis (FMEA) and production part approval process (PPAP) reports and processes were not implemented at that time, so the competence transfer involved was more difficult for external providers. This study highlights the relevance of categorize and differentiate external providers with regards to their material groups’ requirements. Thus, requirements concerning PCB manufacturing are different to the ones for injection molding activities.

The supplier evaluation process suggests that the framework is comprehensive and includes the key considerations highlighted in the interviews, thus offering some insight into possible outcomes for decision makers. The framework is coupled with a decision matrix collecting the information defined in the framework, such as the factors and areas for the operationalization of the process. As observed in the multiple case study, while the relevance of environmental factors is greater than economic factors. The social and environmental criteria were not considered in previous supplier evaluation assessments and, at the beginning, they were underestimated by some participants. However, once they understood the meaning of CSR and its positive influence on firm performance, the social and environmental criteria were adopted.
The research presented in this paper has significant theoretical and practical implications in the supply chain in general and procurement management in particular. Although past literature reviews provide valuable results, they were based upon the assessment of supplier evaluation decisions and did not consider the TBL model in combination with other criteria based on strategic or resource position viewpoints, like Gualandris, Klassen, Vachon and Kalchschmidt (2015). They proposed a sustainable evaluation and verification (SEV) model with three interrelated dimensions: inclusivity, scope, and disclosure. Unlike Winter and Lasch (2016), who stated that the sustainability criteria are less important in supplier evaluation than other criteria, this research assumes that the relevance of social and environmental criteria should be assigned depending on each case study and can be even more relevant than the rest of criteria. Additionally, they did not consider criteria like green energy and energy management, which are highly relevant for environmental responsibility. The supplier evaluation and selection problem has been studied extensively in the literature. However, this paper aims to contribute to the study of the sustainable supplier evaluation literature on supply chain management through the graphical representation of why and how supplier evaluations are made. The proposed framework was successful in the evaluation of the most suitable green external provider and helping decision makers to analyze the suppliers who did not fit with the firm’s policy.

The sustainable supplier evaluation framework presented is intended to address the trends identified in the literature by covering relevant factors considered in supplier evaluation decisions. The objective is to provide a graphical representation of relevant dimensions which need to be studied when examining external provider evaluation decisions. One of the article’s main contributions is the integration of the framework into real-life situations. The consistency of the proposed methodology is confirmed based on two case studies of electronics firms. The carbon emissions reduction is particularly important to bring a more sustainable living environment especially in industrial countries like China. This is supported by Yin, Li, Dong, and Xing (2017) in China and these regulations were observed during the second party audit performed at the Firm B in Shenzhen. Government regulations like water restrictions play an important role. Whereas social conditions are also relevant to guarantee the sustainability, they forgot to consider them in their research. This framework not only includes relevant factors to be considered, but also provides a structure to investigate these factors and design a practical decision matrix with a pairwise comparison methodology for the practical operationalization of the framework. In contrast to
the approach proposed by Sevkli et al. (2007), this thesis develops a framework including sustainability criteria for practitioners and academics to deepen their knowledge in the supplier evaluation field. Results reviewed in the multiple case study support the idea that green supplier evaluation in manufacturing can be effectively addressed with the proposed framework. Additionally, it takes into account the need to determine the weightings of decision makers, as seen in the case studies and comprehensively and understandably document the completed supplier evaluation process through the project sheet and a project report. Further testing of the tool involving the parameters defined in the designed framework are addressed during its operationalization.

In contrast to the research works of Kum, Agarwal, and Sharma (2016); Kumar, Singh and Vaish (2017); and Hashim, Nazam, Yao, Baig, Abrar and Zia-ur-Rehman (2017) who understood the sustainability concept on supply chain in terms of environmental considerations, this study extends this concept by additionally assessing social criteria on supplier evaluations. This study provides a long-term framework for actions in many policy areas and it aims to increase certainty for investment and innovation and ensure that all relevant policies take account of resource efficiency in a balanced manner. Identifying best practices for integrating corporate social responsibility involves the evaluation of external providers’ certification according to the ISO 9001, ISO 14001, ISO 50001 and ISO 45001 standards. Accepting the firm’s code of conduct and monitoring it throughout the whole supply chain phase are relevant factors to be considered in order to ensure procurement sustainability.

The perfect integration of the framework within the proposed tool can be used as a guideline to provide managers, practitioners and academics with a practical solution to make external provider evaluation decisions in a more structured and consistent manner. As observed in the multiple case studies, a better understanding of the lessons learned and improvement potentials should be considered for every future decision, especially by setting a goal which is consistent with the relevance and weighting of the clusters. Hence, practitioners can learn from past failures by adapting future requirements and continuously updating the proposed framework and tool. Therefore, it should be perceived as a support tool for the sustainable evaluation of external providers. The framework will involve a two-stage decision process: (1) the sourcing decision and (2) the managerial actions required to implement the decision.

Notwithstanding the above findings and contributions, this study faces a number of limitations and so do its outcomes. Firstly, a potential limitation of this study stems from the
fact that the in-depth analysis focused exclusively on two case studies. As a consequence, the comparison with other case studies was not evaluated. Secondly, the integration of the TBL methodology into the proposed framework had not been evaluated in the past, which means more evaluations would be required. However, the findings seem to provide a valuable understanding of the current situation in this research field. The present study equally suggests several future research strands which may encourage more intensive studies in this important area.

According to the findings, this article can prove useful for researchers and decision makers, since new trends are emerging in both areas that will probably lead to future research and implementation in firms. Hopefully, the present paper will give rise to a new approach to studying sustainable supplier evaluation practices. It must be added that the results provide practical guidelines to adopt a sourcing strategy based on the relevance of various determinants for the firm. There is clearly still plenty of room for growth and improvement in the sustainable supplier evaluation literature. Another chance for future researchers is empirically validating other case studies within the proposed theoretical framework.

Admittedly, the research topics listed below have already been investigated. Nevertheless, it is my conviction that a need exists to continue updating what is known about sustainable supplier evaluation decision. What considerations are borne in mind during the sustainable procurement decision process? To what extent does the right supplier evaluation have an impact on firms’ operational performance? These and other similar questions should be asked for improving supplier evaluation practices from a sustainable viewpoint.

4.7 References


EXPLORING SUSTAINABLE SUPPLY CHAIN PRACTICES: A CASE STUDY FROM THE GERMAN INDUSTRY
5. Exploring sustainable supply chain practices: a case study from the German industry (Art. 4)

Abstract:
The selection of the appropriate supply chain design is one of the most critical strategic decisions within firms and plays an important role in the material availability and the firm’s profitability. In the last decade, academic research on sustainability has emerged rapidly in the supply chain literature, so there has been insufficient opportunity thus far for the research community to complete a global assessment of sustainable supply chain management designs. This paper seeks to address this need by exploring supply chain management design practices, integrating sustainability and developing a sustainable supply chain design model to help managers select and evaluate the efficiency of their supply chain management designs with regards to customer and product specific needs. A supply chain design decision model based on the ANP (analytic network process) and the TOPSIS methodologies is proposed and validated through a case study in Germany for helping practitioners to put the proposed model into practice. The results suggest that practitioners should implement the model by integrating the proposed framework with a pairwise comparison matrix and a multi-criteria decision analysis based on the TOPSIS methodology to select the supply chain design strategy which most fit their business case. This study not only validates the proposed model through an in-firm case study, but also confirms the relevance of mitigating and avoiding biases when making decisions and to do so define the weight and conditions of decision makers. Interestingly, the paper highlight the relevance of improving firm’s dynamic capabilities by taking into account relevant factors defined in the framework like supplier’s and customer’s interaction.

Keywords: case study, decision framework, sustainability, supply chain management

JEL Codes: M11, L23, L24.

5.1 Introduction

More and more firms have a love-hate relationship between increasing or reducing inventory. On the one hand, inventory generates a temporary loss for the firm, while on the other it is necessary to build up safety stocks so that firms can improve delivery times, get product to
market faster and exceed their customers’ expectations. Inventory becomes increasingly expensive over time, which means the longer a firm holds its inventory, the costlier it becomes. What makes the situation even worse is the fact that many firms fail to take into account dynamic capabilities once they choose a supply chain design to build up their inventory. According to Teece, Pisano and Shuen (1997), “dynamic capabilities are the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments”. Product innovation and organizational structure reconfiguration are examples of dynamic capabilities allowing firms to reconfigure their business units and recombine resources to adapt to environmental changes and provide a better performance (Ambrosini and Bowman, 2009). Dynamic capabilities are extremely important to efficiently react to market changes, for instance, when prices of components are increasing or the components are not available on the market or their lead times are extended.

The electronic component market is again facing shortages and causing original equipment manufacturers (OEM) and electronics manufacturing services (EMS) providers a real headache. Unfortunately, the current marketplace situation, with shortages of electronic and other components due to allocation, is certainly one of those times, and the conditions are still not improving and are set to continue in this way into 2019 (Sharp, 2018) (Baldock, 2018) (Future Electronics, 2018). Even if firms sign a consignment stock agreement with their suppliers and confirm their customer orders, delivery dates will be extended and final products will be more expensive. Probably this is not the time to ignore either market indicators or suppliers’ resource positions. A risk is also taken when switching to a supplier that firms do not have experience with. Moreover, this way of purchasing requires more administrative costs and renegotiating efforts, and it can also delay the fulfillment of firms’ new stock.

Taking as a starting point the electronic component market, the aim of this paper is to explore and update the supply chain literature by identifying past trends and developing a supply chain design model containing economic, environmental and social dimensions. As an OEM, it is easy to lose touch with what is going on in the component marketplace – particularly when firms have taken the strategic decision to outsource their manufacturing to their external provider. In contrast to the majority of recent works, focused on minimizing cost or maximizing profit, this study addresses not only economic but also sustainability-related
criteria in designing an effective and efficient supply chain strategy by proposing a supply chain design model.

The rest of the paper is organized as follows: Section 5.2 provides the literature review on supply chain management. In Section 5.3, the nine-stage supply chain design (SCD) model proposed is presented and described. In Section 5.4, the proposed model is explained and validated via a case study. Then, trends from experimental evaluations and analyzes are presented in order to assess the effectiveness and efficiency of the proposed model in Section 5.5. Finally, the main conclusions and the topics related to this study which might be researched in the future as well as the limitations are presented in Section 5.6.

5.2 Literature review on supply chain management

Even though the dilemma faced by managers when it comes to choosing between agile or lean supply chain strategies has been studied by many researchers in the past, hybrid and multiple strategies involving sustainability aspects have not been considered. Whereas hybrid strategies refer to the combination of agile and lean strategies, multiple strategies result from the simultaneous use of supply chain management designs. Lean SCD is concerned with eliminating all the non-value-adding processes and thereby minimizing costs and cycle times (Hines and Rich, 1997), improving the quality and availability of the product (Vrijhoef and Koskela, 2000) through upstream and downstream flows of products, services and information that collaboratively work (Vitasek, Manrodt and Abbott, 2005). Whereas Tasdemir and Gazo (2018) stated that there is a need to develop a versatile tool that has the capability to assess and benchmark efficiency and sustainability of organizations and their supply chains, Martínez León and Calvo-Amodio (2017) posed the need for a consensus on definitions of lean and sustainability for achieving a successful integration.

Agile SCD, conversely, is suggested where demand is volatile and speed is the priority and concerned with the ability to quickly react to volatile demand and market characteristics in a priority manner (Mason-Jones, Naylo and Towill, 2000; Agarwal, Shankar and Tiwari, 2006) (source-to-order and market responsive). Hybrid strategies (leagile SCD strategies) are a combination of both methodologies and have been discussed by authors like Beck (2013), Christopher and Towill (2002), Haq and Boddu (2017), Olhager (2003, 2010) and Sun et al. (2008). Haq and Boddu (2017) posed that the leagile supply chain management paradigm
which includes both lean and agile principles has attained greater importance in scenarios governed by unstable market trends, increased product variety and demand fluctuations. Whereas the forecast-driven strategy preferred the make-to-stock (MtS), deliver-to-order (DtO) and assemble-to-order (AtO) strategies, the customer order-driven strategy is more suitable for the make-to-order (MtO), source-to-order (StO) and engineer-to-order (EtO) supply chain situations. Dallasega, Rauch and Frosolini (2018) presented “a lean approach for in engineer-to-order construction projects” splitting the job order in small lots allowing an optimal capacity saturation and reduction of non-productive and waste time. According to Olhager (2010) the customer order decoupling point (CODP) divides the material flow that is forecast-driven (upstream of the CODP) from the flow that is customer order-driven (downstream of the CODP). Thus, the positioning inventory in the supply chain is planned gradually according to its level with finished, semi-finished goods, and the stockage of assembly groups, components and raw material from tier 1-n. A lean supply chain should be applied for the upstream phase, while an agile supply chain would be more suitable for downstream operations (Olhager, 2010). Leagile supply chains would be more suitable for middle point operations of the CODP like assemble-to-order (AtO) SCD (Beck, 2013).

The appropriate supply chain design should be selected in a structured, systematic and consistent manner. While Kumar BR, Agarwal and Sharma (2016) considered the environmental aspects in the design of supply chain strategies based on lean supply chains, Fathollahi-Fard, Hajiaighaei-Keshteli and Mirjalili (2018) developed a multi-objective stochastic closed-loop supply chain network design with social considerations. According to them, most current studies consider the economic aspects and just a few works present social considerations to design a supply chain network.

### 5.3 Sustainable supply chain design decision model

The question was how to implement supply chain management principles in daily business reality. According to Shan and Wang (2018) there is a need to integrate environmental considerations into supply chain management. Thus, a model with an integrated framework to implement sustainable supply chain practices to solve this problem in a structured manner is proposed in this section.
The paper focuses on the procurement phase between firms and their suppliers and the design of the most suitable SCD strategy to meet the respective customer and product needs. The phases of firms’ internal processes, distribution and customer delivery as part of the SCD strategy are not included in this study, as they are addressed in another paper. The proposed supply chain design decision model is based on the ANP\(^2\) (analytic network process) methodology which was developed by Saaty (1996) and the subsequent implementations by Gencer and Gürpınar (2007). The model was split into 9 steps: (1) analyzing of customer group; (2) analyzing of product group; (3) analyzing of external providers; (4) determining the goal and SCD criteria from the framework; (5) determining the alternative of external providers; (6) defining the weight of decision makers; (7) building different SCD scenarios; (8) making the paired comparison matrices (PCM); and (9) decision with the evaluation of preferred SCD using the TOPSIS methodology. Figure 5-1 illustrates the proposed model.

(1) The first process is analyzing customers who are interested in a specific product or service and classifying them into customer groups. For the assessment and definition of the different customer groups (CG), criteria like the interaction of the firm with the customers in terms of information sharing, collaboration, demanded influence on distribution and manufacturing are evaluated. Thus, future customers can be evaluated according to the above-mentioned criteria and classified into the previously defined CGs.

\(^2\) ANP structures a decision problem into a network and is used in multi-criteria decision analysis (Saaty, 1996).
(2) Secondly, the following criteria are considered for **analyzing the product group**: (1) duration of the product lifecycle; (2) windows for delivery; (3) demand volume; (4) demand variability; and (5) product variability. The evaluation is performed by rating the above-mentioned criteria and taking their interrelation into account.

(3) Thirdly, the **analysis of external providers** is performed by a multidisciplinary team mainly comprising the following: strategic purchasers, supplier quality managers, designers, developers and other players involved in the process, like industrial engineers. As part of the analysis of external providers, the corporate social responsibility (CSR) criterion is taken into account. The CSR considerations are subcategorized into the evaluation of environmental criteria (ISO 14001), occupational health and safety (ISO 45001), green energy (ISO 50001), conflict minerals (CMRT & REACH & RoHS) and the implementation of internal and second party codes of conduct (CoC). Interestingly, the interaction with Tier 1-2-...-n suppliers is taken into account as a key relevant criterion for the consideration and evaluation of the whole supply chain.
(4) The fourth process is defining the goal and determining the most relevant criteria and sub-criteria from the framework which must be highlighted and prioritized. A project with a milestone plan has to be set up. The definition of the required resources as well as the appointment of a project leader is more than mandatory to monitor and organize the tasks that different team members must deliver to meet the defined schedule. The framework is based on the definition proposed by Beck (2013) and further developed with the criteria regarding CSR sustainability and interaction with tier 1-n suppliers. The framework is illustrated in Figure 5-2.
Figure 5.2. The proposed SCD decision framework.

Source: own source, developed from Beck’s (2013) framework.
(5) The next step is determining alternative of external providers in order to avoid possible shortages or interruptions in the supply chain structure. The interaction with tier 1-2-n for existing and alternative suppliers must be evaluated in terms of (1) information sharing; (2) supply chain risks; (2) market stability; (3) supplier resource position; (4) demanded influence on distribution; (5) demanded influence on manufacturing; and (6) collaboration. The will of the supplier to share information and confidential documentation with the firm, the trust in the supplier and the bidirectional collaboration with the focus on a win-to-win situation is even more relevant than just the economic criterion. The long-term relationship with suppliers can influence the firm to work with suppliers in the future because of positive results in the past.

(6) When choosing decision makers (DM) for the evaluation of different SCD scenarios, the ones selected for this study were those decision makers within the procurement process who were most willing to explain the decisions made at their workplace. Those decision makers are categorized into three levels: DM1, who are represented by purchase leaders; DM2, operative purchasers; and DM3, strategic purchasers. The weight of decision maker levels is set as follows according to the Boran et al. (2009)'s research: DM1 is 0.406; DM2 is 0.238; and DM3 is 0.356, so that the total of the weighting is 1. In order to perform an assessment a minimum of three cross functional decision makers must be involved and they must be trained in order to mitigate and avoid biases when making decisions.

(7) Different SCD scenarios are built by the above-mentioned decision makers in accordance with the CG and PG by means of this framework. In general, the material decoupling point refers to the physical allocation of the goods and indicates how deeply the customer order penetrates into the physical flow (Hoekstra and Romme 1992). The factors considered in the SCD are the distribution channel, the SC strategy, the SC type, and the position of the decoupling point (Table 5-1). The information decoupling point is where information turns from the high value actual consumer demand data to the typical upstream distorted, magnified and delayed order data (Mason-Jones and Towill 1999). The consideration of a suitable SC type includes the positioning of the decoupling point (Olhager, 2003). Market information is mostly used to improve demand forecasts and enhance the operating capabilities, and it does not necessarily have to stop at the (material flow related) CODP (Olhager 2012).
A high interaction with the end customer, which includes frequently sharing sensitive information and forecasts, makes it possible to identify the value chain for a product. Whereas upstream of CODP is the form of “push” where the release of work is governed by forecasts and assumptions, downstream operations are the form of “pull” activities in which the goods are planned and control based upon actual end customer orders. The collection of processes associated with ordering materials (raw materials, semi-finished products, finished products, goods, merchandise) and/or services for specific orders.

Table 5-1. Type of Supply Chain Design

<table>
<thead>
<tr>
<th>Type of SCD</th>
<th>SCD strategy</th>
<th>Type of CODP (customer order decoupling point)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make-to-Stock (MtS)</td>
<td>Lean</td>
<td>Upstream</td>
<td>Serving customers from finished goods inventory, keeping inventory in the distribution system, distributors, etc.</td>
</tr>
<tr>
<td>Deliver-to-Order (DtO)</td>
<td>Lean</td>
<td>Upstream</td>
<td>The deliver process that facilitates make-to-order.</td>
</tr>
<tr>
<td>Assemble-to-Order (AtO)</td>
<td>Leagile / Lean</td>
<td>Up- &amp; medium stream</td>
<td>A number of preassembled modules are combined to meet customer’s specifications; alternative components are carried in inventory.</td>
</tr>
<tr>
<td>Engineer-to-Order (EtO)</td>
<td>Leagile / Agile</td>
<td>Downstream</td>
<td>Working together with the customer to design and make the product.</td>
</tr>
<tr>
<td>Make-to-Order (MtO)</td>
<td>Agile</td>
<td>Downstream</td>
<td>Customer’s product is made from the raw materials, parts and components, preferred for products with a wide range and low individual product volume per period.</td>
</tr>
<tr>
<td>Source-to-Order (StO)</td>
<td>Agile</td>
<td>Downstream</td>
<td>Order materials for explicit – identifiable – downstream demand.</td>
</tr>
</tbody>
</table>

Source: own source

A specific reference or customer order detail is exchanged with the supplying party, attached to or marked on the product, recorded in the warehousing or enterprise resource planning (ERP) system to track individual deliveries. Source-to-order is a MtO process which is preferred in cases like (1) purchasing to order; (2) just-in-time; (3) in a factory: ordering of configurable parts; and (4) in a retail store: special orders. Investing in research by creating a methodology for defining the “optimal” position of CODP for a closer and mutually beneficial cooperation with the suppliers and customers to improve customer satisfaction drives the focus on shifting CODP in upstream.
(8) The eighth process step corresponds to the assessment (rating) of the *paired comparison matrices* (PCM). The decision makers involved are mainly the purchase leaders, and strategic and operative purchasers who are asked to respond to a series of pairwise comparisons where two criteria elements at a time are compared in terms of how they contribute to their corresponding upper level criterion. The consistency of each comparison was also checked in this step. The relative importance values are determined on a scale of 0 to 2, where a score of 0 represents less importance than the other criterion, a score of 1 indicates equal importance between the two elements, and a score of 2 indicates the maximum importance of one element (row component in the matrix) compared to the other one (column component in the matrix). The weighting of each criterion was then determined and adapted in the pairwise comparison matrix.

(9) Finally, a decision is taken based on the evaluation of the preferred SC design through a matrix built using the underlying logic of the technique for order preference by similarity to ideal solution (TOPSIS) and the criteria defined in the framework. The calculation of the matrix is based on the procedure defined in the research by Temuçin et al. (2013) and it is not explained in this study because is not the target of the present paper. TOPSIS is a well-known multiple criteria decision-making (MCDM) method which was originally developed by Hwang and Yoon (1981) to solve real-world decision problems. The TOPSIS method chooses alternatives that have shortest distance from positive ideal solution. The TOPSIS method has been analyzed using multi-criteria models for complex decisions and multiple attribute models for the most preferable choice. Based on the matrix, each condition is evaluated on a scale of 1 to 5, where a score of 1 means that the condition does not meet the requirements, a score of 2 indicates that the requirements are only partly met, a score of 3 indicates that the requirements are almost completely fulfilled, a score of 4 means that the requirements are fully met and a score of 5 indicates that the condition reaches a level of excellence. The weightings of each criterion are then determined and adapted in the matrix. The best evaluated SCD scenario is the most recommended and the preferred one. However, multiple SCD scenarios can be applied depending on customer and product groups.

### 5.4 An illustration of the model using a case study

The case study will be useful to understand how supply chain design decisions are made in the practice. Lessons learned from interviews with decision makers (operative, strategic and lead purchasers) are collected in order to understand the interrelation between the firm, third
parties and the factors and possible outcomes of SCD decision processes. In order to do this, an ongoing SCD decision considering the existing allocation issues in the electronic marketplace within an in-firm case study was analyzed and reviewed. Hence, a number of interviews were undertaken with decision makers at an electronic German firm. The interviews, their design, the analysis of the transcripts and how the findings were incorporated into the framework are described here.

Semi-structured interviews with operative, strategic and lead purchasers were conducted. An interview questionnaire with a preliminary framework was designed based on Beck’s (2013) research and served as an interview guide. Interview sessions took slots of over one hour and mainly covered the following topics:

- details of the interviewee
- areas related to the SCD
- triggers for SCD selection
- criteria to be considered during the SCD process
- functions involved in the SCD process
- relevant criteria for the SCD decision taken in the organization
- relevant financial elements during the SCD decision process
- strengths and weaknesses of ongoing and past decisions
- lessons learned and suggestions from ongoing and past decisions
- stages taken into account during the SCD decision process

The firm that was the object of the case study is a leading manufacturer of electrical products certified on NEC, CEC, ATEX, GOST, Inmetro and IECEx standards. The firm is a global player based in Germany with 1,788 employees and a €286.6 million turnover (key figures from the end of 2016). The main criteria for selection were that the firm had recently made SCD decisions on a specific product and that the author has a professional relationship with the firm.

To undertake the in-firm case study, information was collected on how previous SCD decisions had been approached. The case study was carried out using evidence from multiple sources, such as a consignment stock agreement (CSA), a non-disclosure agreement (NDA), a confidential disclosure agreement (CDA), supplier self-disclosure forms, supplier selection assessments, quality assurance agreements (QAAs), supplier audit reports, delivery contracts, purchase orders, regular communication transcripts, final reports, demand planning and forecasting configuration at SAP and project plans, with a view to validity and reliability (Yin, 1994 and 2018). The case study will also be useful to refine the model and illustrate
how to use this framework. The external provider involved in this case study is an experienced printed circuit board assembly (PCBA) and electronics manufacturing services provider.

The firm is based in Germany and belongs to a Dutch corporation which is listed in the Reed Electronics Research Report of TOP European EMS-Providers in 2018. It has approximately 2,750 employees and a €439 million revenue (key figures from 2017). The firm is ISO 9001 (manufacturing), ISO/TS 16949 (automotive) and ISO 13485 (medicine) certified and also complies with RoHS, REACH and conflict minerals directives. Additionally, the firm has an internal code of conduct (CoC) which contains the main social criteria defined in ISO 26000. Yearly environmental and social targets are defined, documented and monitored. The firm obtained a green energy certificate according to ISO 50001 standards and its firm facility environmental control system is ISO 14001-certified.

5.4.1 Case study

In the following pages, the previously model drawn in Figure 5-1 is proposed to the case study. As an example for the implementation of the proposed model, three different scenarios are built. The scenarios’ outcomes are specific for the evaluated AZ product, which is a product with low demand and high variability characteristics. Whereas for this specific case study only three stages in SC are drawn, the model is not limited to these three stages.

(1) Analyzing of customer groups

The firm’s customers were analyzed and categorized according to the decision makers into four different groups which are listed in Table 5-2. The four different groups were evaluated according to the information requested by customers: information sharing, distribution, manufacturing, sourcing and customer interaction and CSR criteria.

Table 5-2. Customer group classification

<table>
<thead>
<tr>
<th>Customer Group</th>
<th>Information sharing</th>
<th>Distribution</th>
<th>Manufacturing</th>
<th>Sourcing</th>
<th>CSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CG 1 (large projects) Customer specific</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>CG2 (medium-small projects) Customer specific</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>CG3 (day-to-day operations) Customer specific</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>CG4 (day-to-day operations) Standard specification</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Source: case study
(2) Analyzing of product groups

Within the product or material group the products were classified according to the product groups defined in the firm based on the ABC-XYZ analysis tool which is used for the inventory management. This tool is implemented as part of the ERP system (SAP) of the firm and helps the firm focus on its most important stock-keeping units (SKUs). The product group classification is illustrated in Figure 5-3. ABC analysis is a method of increasing the efficiency and effectiveness of the firm's sales and purchase system. The most common method of ABC analysis is used to optimize the range of goods (assortment) and its inventories in order to increase sales by identifying the most promising groups of products that bring the maximum profit for the firm (Chichulina and Skryl, 2018). This type of analysis is based on Pareto’s rule: “20% of the products provide 80% of the firm’s profits.” In conducting product analysis, all goods are divided into three groups: Group “A” - the most valuable goods; Group “B” - medium-value goods; and Group "C" - low-value goods.

Figure 5-3. Product group classification

<table>
<thead>
<tr>
<th>Inventory Optimization ABC-XYZ Analysis</th>
<th>Sales frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>X</td>
</tr>
<tr>
<td>Medium</td>
<td>Y</td>
</tr>
<tr>
<td>Low</td>
<td>Z</td>
</tr>
<tr>
<td>X</td>
<td>AX</td>
</tr>
<tr>
<td>Y</td>
<td>AY</td>
</tr>
<tr>
<td>Z</td>
<td>AZ</td>
</tr>
<tr>
<td>B</td>
<td>BX</td>
</tr>
<tr>
<td>C</td>
<td>BY</td>
</tr>
<tr>
<td></td>
<td>BZ</td>
</tr>
<tr>
<td></td>
<td>CX</td>
</tr>
<tr>
<td></td>
<td>CY</td>
</tr>
<tr>
<td></td>
<td>CZ</td>
</tr>
</tbody>
</table>

Source: case study

In order to take into account the randomness of sales and purchases, XYZ analysis is used. This method evaluates the stability of certain objects or processes (product sales, customer behavior, supplier behavior, employee efficiency, etc.). For instance, XYZ analysis makes it possible to group the firm’s products according to the demand for a product over a period of time. Indeed, once the coefficients of variation of indicators of sales and purchases of goods for specified periods are determined, the goods are grouped accordingly into categories X, Y and Z. The coefficient of variation is very significant and representative and is calculated using the standard deviation and the mean ($CV = \sigma/\mu$). The window for delivery depends on the coefficient of variation.

Group X comprises goods that are characterized by stable demand (volume of purchases); therefore, there is a high probability of correct forecasting of purchases and sales. This is defined in the firm for products which are purchased monthly and for which, therefore, the
value of the coefficient of variation is low. Group Y includes commodities with some fluctuations in sales volume. Forecasts on these products have average reliability. This is defined in the firm for products which are purchased quarterly and for which the value of the coefficient of variation is therefore medium. Group Z comprises products with irregular and unstable demand which are purchased yearly and for which sales cannot be forecast accurately. The value of the coefficient of variation is high. Whereas AX, BX and CX products are characterized by high trade turnover and stability and there is no need to create an excessive safety stock, the consumption stability for AY, BY and CY groups is low; therefore, it is recommended to increase their safety stock. AZ, BZ and CZ products are characterized by low predictability of consumption, which means it is difficult to plan an appropriate forecast (Chichulina and Skryl, 2018).

The use of XYZ analysis can greatly reduce the time that a manager spends managing and controlling the products of this group. This case study focuses on a product which belongs to the worst combination, AZ. This product is a Field Device Coupler certified with IECEX and ATEX standards and can be used for fieldbus devices on the High Power Trunk protected by a short-circuit limiting function. An attempt to ensure the guaranteed presence of this product will lead to a significant increase in the average inventory of the enterprise. In the purchasing tab of the material master, purchasers can specify a manufacturer part profile. Thus, in the case study for the AZ product, the procurement related requirements are set and specified in SAP within the Manufacturer Part Number (MPN) - Material Requirements Planning (MRP) (see Figure 5-4). The replenishment lead time was set by 56 days and the minimum lot size by 24. Three days were set for performing incoming quality inspections.

Figure 5-4. AZ Product- Material Requirements Planning (MRP)
No safety stock is available in the firm, but consignment stock is held at the supplier’s warehouse named as “PS02”, which is contractually agreed with the supplier. The minimum purchase order (PO) sized is defined according to the coefficient of variation, which is automatically calculated via SAP.

(3) The analysis of external providers was performed previously. Two suppliers were qualified to manufacture this product. However, it was internally decided to allocate the manufacturing of the product only to the supplier mentioned above, which has a manufacturing plant in Germany.

(4) Determining the goal and SCD criteria from the framework. This product is intended to enter into a market share and meet some customer-specific requirements. The most critical viewpoint was the higher coefficient of variation, and the target is to shift the product from the AZ categorization into the AX, AY, BX, BY categories. However, set-up costs for tooling and adapter tests must be invested.

(5) Determining alternative of external providers. Two suppliers were qualified and able to perform the manufacturing and testing processes of the product mentioned above. A second source supplier was already qualified and future purchase orders could be shifted to the alternative supplier.

(6) The weight of decision makers (operative and strategic purchasers and purchaser leaders) was previously defined in Section 5.3 (6) and was applied for the evaluation of the different SCD scenarios.

(7) Three different SCD scenarios were built by the decision makers taking into account the above customer groups with varying levels of customer interaction each group requires. For instance, SC design scenarios are derived according to several possibilities to serve these
customer groups. Interestingly, the downstream of the customer order decoupling point in this case study strongly influences the output of all three scenarios.

a) **SC design scenario 1** considers a single SC design to serve the customer groups. Since the customer groups vary in terms of the information exchange they require, the firm must offer them various possibilities to submit their orders. Therefore, the firm would adopt a multichannel distribution strategy based on the supply from two external providers. Hence, it seems appropriate to adopt a leagile approach in a single SC design and to implement an EtO SC. Whereas the combination of multiple sourcing will increase the material costs and extremely increase the SC costs, the firm will have a better resource position to quickly supply its customers with low demand and high variability to fulfill the demand for a high customer influence on manufacturing. Moreover, the firm would be forced to manufacture the AZ product with low demand and high variability by means of MtS SC, which may involve extensive costs for storing these units.

b) **SC design scenario 2** adopts a single SC strategy based on a direct distribution focused on a single source strategy from a qualified supplier located in Germany. The firm signed a consignment stock agreement and agreed a minimum safety stock with its supplier to keep a defined amount of stock in the supplier’s inventory. Bill of Material (BOM) is cheaper for its supplier as the supplier purchases large amounts of electronic components. Due to the high coefficient of variation, the agile strategy would be the most suitable one based on the StO SCD type. Whereas the effectiveness of the SC cost using this SCD is higher, the firm’s dependency on its supplier and the supplier’s resource position can extend its window for delivery and its response to the customers. The firm can use the flextime system to increase or decrease its workforce resources if customer orders increase or decrease, efficiently saving its own resources.

c) **SC design scenario 3** incorporates the set-up of a single SCD based on a direct distribution channel. An agile strategy by means of an MtO SCD seems to be most suitable one to deal with the low demand and high variability of the product. This approach is cost-efficiency oriented and at the same time limited by the low level of customer interaction. Increasing customer interaction can help the firm have better forecast data and shift the product to the AX or AY area, which is most beneficial for increasing the firm’s revenue. The position of the product within the different SCD scenarios is summarized in Figure 5-5.
(8) Making the paired comparison matrices (PCM). For the weighting of the criteria pairwise comparisons were used for the different criteria from the framework which were applied to the three SCD scenarios. After the assessment, CSR and the cost of the SC design were defined as the most relevant criteria in the SCD decision. As presented in Figure 5-6, within the sub-criteria of CSR, the code of conduct and social responsibility are the most important criteria. In the area of product and demand analysis, the criteria of demand volume and variability have the greatest weight. A possible revenue increase is the most important criterion within the positive effects of SCD. Customer interaction, supplier interaction and product and demand are of equal importance.
Figure 5-6. Pairwise comparison

<table>
<thead>
<tr>
<th>Pairwise comparison</th>
<th>Determine the weights of criteria</th>
<th>Customer interaction</th>
<th>Supplier interaction (Tier 1-2.)</th>
<th>Product and demand analysis</th>
<th>CSR</th>
<th>Positive effects of SC design</th>
<th>Costs of SC design</th>
<th>Weight (%)/Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Customer interaction</td>
<td>2 1 1 1 0 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Supplier interaction (Tier 1-2.)</td>
<td>1 2 1 1 1 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Product and demand analysis</td>
<td>1 1 2 1 0 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 CSR</td>
<td>2 2 1 1 1 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOP1 ISO 14001</td>
<td>2 2 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>TOP2 ISO 45001</td>
<td>2 2 1 1 1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOP3 Code of Conduct</td>
<td>2 2 2 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>TOP4 Conflict minerals (CMRT &amp; REACH &amp; RoHS)</td>
<td>2 2 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOP5 ISO 50001</td>
<td>2 1 1 1 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Positive effects of SC design</td>
<td>2 2 2 1 0 9</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Costs of SC design</td>
<td>2 2 2 1 1 10</td>
<td></td>
<td></td>
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</table>

Source: case study

(9) **TOPSIS application for the evaluation of supply chain design scenarios.** Once the three design scenarios had been derived by means of the framework, a decision matrix based on the TOPSIS methodology was used to select the most appropriate SCD for the case study. Since the priorities of the pairwise comparison favor different solutions, an assessment of the different SCD was conducted, with a focus on the approach to the closest ideal solution. All sub-criteria were integrated, and every main criterion was rated by the above-mentioned decision makers. After the evaluation of the defined SCD, scenario 3 seemed to be the ideal solution from the three cases, with a score of 87% out of a maximum of 100%, followed by scenario 2 with 77% and, finally, scenario 1 with a score of 59%. The SCD comparison is displayed in Figure 5-7.
Figure 5-7. Supply Chain Design comparison

5.5 Theoretical and managerial implications of the research findings

5.5.1 Theoretical implications

Admittedly, a developed model was proposed in Section 5.3, which introduces a cause-effect relationship between the relevant criteria as well as variables and the standardized decision matrix. Additionally, an MCDM application combined with the TOPSIS methodology is introduced to as an efficient tool for resolving decision matrices. This combined application was developed by means of the literature review and is applied and validated through the firm’s case study. The need to apply MCDM methodologies in the SCM was mentioned by different researchers in the past (Beck, 2013). Hence, this research proposes the MCDM methodology combined with the TOPSIS for resolving supply chain design decisions. Even although the MCDM methodology is not new, this methodology is choosing because of its efficiency and is adapted in this research and validated through the case study for addressing SCD decisions in a systematic manner.
In order to perform an assessment a minimum of three cross functional decision makers must be involved and they must be trained in order to mitigate and avoid biases when making decisions. The novelty of this research compared to past researchers is the proposal of fixed and not fuzzy decision makers’ weights when making decisions using the TOPSIS methodology.

### 5.5.2 Managerial implications

A supply chain design decision model is proposed to help managers to design an appropriate supply chain design strategy according to their needs. This proposed model collected the inputs from the procurement problems faced by managers at the electronic market in 2018. Shortages and long delivery delays are faced by many firms because of the high demand of particular electronic components in the market. This was reflected in this study as a set of interviews with affected practitioners was performed. Forecasts planning and second source strategies are key in order to prevent or mitigate the shortage’s effects. Through the results of the empirical research phase an SCD-decision model is now available for managers to help them to design the appropriate supply chain strategy for a certain product or product group.

An evaluation of opportunities and risks for products in general and products with low demand and high variability in particular like the aforementioned “AZ” products is complexed and at the same time there is a need for firms to evaluate and prevent possible risks. However, the selection of the right supplier for this product type and the development of a collaborative supply chain management (CSCM) strategy can help firms solve, avoid or minimize shortage issues, thus favoring a win-to-win and long-term partnership situation. It was observed that there are some trends from experimental evaluations to take into account to improve firms’ sustainable supply chain practices and supply SCD selection effectiveness:

1. **Taking into account second sources and alternative components and designs during the R&D phase** so that different electronic components are qualified and can be assembled if other parts are not available on the market. Listing alternative devices on their bill of materials (BOM) or separate approved vendors list (AVL) will make it easy for external providers to explore all options when they hit a supply issue. The engineering team should be in charge of reviewing the parts list to make sure every option can be explored in detail when allocation strikes. These components should be included in the firm’s standard sheets.
2. **Increasing customer interaction**, trying to increase the regular communication with customers, sharing information, forecasts, trends and information on possible future projects will shift the CODP from downstream to upstream.

3. **Focusing on activating the firm’s suppliers and increasing the interaction with suppliers** from the beginning of new projects, with a preference for an upstream decoupling point based on forecasts and not only on actual customer orders, so that the window for delivery is decreased, favoring the increase in customers’ expectations. It is also beneficial to share demand forecasts as much as possible with external providers so that they can procure the required component with their supply chain partners. Admittedly, a quick response to price and lead-time issues with external providers helps external suppliers quickly source the required material on the market without losing too much time in extra-costs agreements and extending lead times. Keramydas et al. (2017) proposed a methodology to minimize costs and CO2 emissions in supply chain network design; however, the interaction with tier 1-n suppliers and customers is key not only in reducing costs and CO2 emissions, but also in improving delivery times and collaboration, as well as in shifting to an upstream decoupling point.

4. **Reconfiguring organizational structures to improve internal and external dynamic capabilities.** Increasing the internal and external flow information is highly relevant for customers, external providers and the sales team to be regularly informed about the ongoing marketplace situation. While price increases often associated with allocation create conflicting involving suppliers, customers and end customers, explaining the reasoning behind them to customers can improve the customer-supplier relationship. Adequate actions should be adopted together with the marketing and sales departments to promote Z products into X and Y areas so that the SCD strategy can be changed and the profit can increase.

5. In addition to the trends proposed by Sharp (2018), the present study advocates the need to promote and adopt internal and external policies to guarantee CSR criteria all along the supply chain (tier 1-n) by preparing codes of conduct (CoC) for suppliers and subcontractors. This thesis is aligned with the Emamisaleh, Rahmani and Iranzadeh (2018)’s research of implementing a methodology for improving sustainable supplier management practices.

6. **Collaborative relationship with suppliers and customers** improved supply chain performance in several core areas. Trusting external providers and their buying team and supporting them in the raw material procurement process if firms have better material
conditions and better networks. Customer meetings should be intensified to speed up critical orders (picking lists) and prioritize parts to complete full orders and finalize customers’ orders quickly. A list of complete parts to complete the end customer’s order should be specified and shared with the supplier (only for project-related orders). This is supported by the Haq and Boddu (2017)’s research results.

7. **Optimizing the supplier’s resource position through the 7Ms** (machine, method, material, manpower, measurement, milieu and management). For instance, in the case study the supplier introduced a new SMD line to increase its production capacity.

8. **Monitoring suppliers and the market through defined KPIs** and performing supplier and subcontractor audits help anticipate trends. Information on replenishment lead times should be regularly updated into the ERP system (SAP) to have up-to-date figures and be able to determine realistic customer order confirmations. MRP is needed to procure the required quantities on time for fulfilling customer demands. It is also necessary to focus on both quality and on-time deliveries by establishing a system of rewards and economic sanctions in suppliers’ contractual agreements depending on results. External providers should be asked to revalidate their quotations in terms of pricing, delivery and stock liabilities prior to sending them an official order to make sure they can still meet the agreed price and delivery expectations, even if a service level agreement (SLA) is in place. Electronic data interchange (EDI) and IT tools facilitate improved forecasts, management and reduced inventory and costs (Miao and Diu, 2013).

### 5.6 Conclusion, limitations and future research

The research presented in this paper has significant theoretical and practical implications in the supply chain design management in general and the electronic marketplace in particular. There has been significant claim of further studies on the development of operational tools for SCD decisions. This paper presented a currently discussed problem about the design of differentiated SCs in order to avoid or offset the effects of allocation issues in the electronic marketplace. Although past literature reviews like Beck (2013) provide valuable results, they were based upon the assessment of SCD decisions failing to consider the CSR sustainable and the tier 1-n interaction criteria. The findings from this article also highlight the importance of addressing SCD decisions in a structured manner, prioritizing the development of dynamic capabilities in order to improve the firm’s ability to reconfigure internal and external competences to address rapidly changing environments and reinforce a collaborative supply
chain management (CSCM) system with third parties. In contrast to the research works of Fathollahi-Farda, Hajiaghaei-Keshteli and Mirjalili (2018), who understood the concept of supply chain sustainability in social terms, this study extends this concept by additionally assessing environmental criteria in supply chain network design evaluations. A multidisciplinary team should evaluate the possible risks and chances involved in dealing with SCD decisions through a suitable and adapted assessment tool. A nine-stage model for the SCD decision process which follows the trends observed in the literature reviewed has been proposed. This paper aims to contribute to the study of the SCD literature on supply chain management through the graphical representation of how SCD decisions are made, integrating sustainability aspects to resolve supply chain design decisions. Interestingly, the paper presents relevant dimensions and factors to be studied and evaluates possible outcomes in approaching SCD decisions. While Kumar BR, Agarwal and Sharma (2016) considered the environmental aspects in the design of lean supply chain strategies, this article proposes a model where decision makers can evaluate which SC type (lean, agile, agile) best fits the specific customer needs and product characteristics. Whereas Pinto Taborga, Lusa and Coves (2018) proposed a methodology based mainly on the corporate carbon strategy and the carbon emission roadmap, this paper argues that a sustainable supply chain strategy should consider customers, stakeholders and specific product requirements. Thus, sustainable strategies for PCB manufacturers would be different than for sheet molding compound (SMC) or elastomer manufacturers.

The perfect integration of the framework within the proposed tool provides managers, practitioners and academics with a practical solution to make decisions in a more structured and consistent manner. As observed in the case study, a better understanding of the lessons learned and improvement potentials should be considered for every future SCD decision. Hence, practitioners can learn from past failures by adapting future requirements and continuously updating the proposed framework and tool. The proposed model will involve a two-stage decision process: (1) the SCD decision and (2) the managerial actions required to implement the decision. Notwithstanding the above findings and contributions, this study faces a number of limitations and so do its outcomes. Firstly, a potential limitation of this study stems from the fact that the in-depth analysis it presents is focused exclusively on one case study. As a consequence, the comparison with other case studies was not evaluated. Secondly, the development and integration of the presented model into a decision support methodology can be addressed. However, the findings from this study seem to provide a valuable understanding of the current situation in this research field. The present paper
equally suggests several future research strands which may encourage more intensive studies in this important area. Researchers can develop the proposed framework integrating additional criteria for the evaluation and the prioritization of scenarios with the TOPSIS to enhance the approach’s effectiveness. This paper presented a case study from the electronic industry. Case studies from other sectors can also be considered. Some specific research questions that can be explored in the future include: What are the challenges of Lean, Leagile, Agile and CSR implementation? Does the implementation of Lean and sustainability assist firms to be more efficient? Does the inclusion of the CSR criteria within the supply chain design decisions calls for a new theoretical foundation for quality improvement? Do the implications described in Section 5.5.2 differ from other countries?

This article can prove useful for researchers and decision makers, since new trends are emerging in both areas that will probably lead to future research and implementation in firms. Hopefully, the present paper will give rise to a new approach to SCD decision practices. Nevertheless, a need exists to continue updating what is known about SCD decisions.

5.7 References


INTEGRATION OF SUSTAINABILITY ASPECTS IN THE SUPPLIER SELECTION PROCESS: A CASE STUDY FROM A GERMAN ELECTRONICS FIRM
6. Integration of sustainability aspects in the supplier selection process: a case study from a German electronics firm (Art. 5)

Abstract

The supplier selection process has become an important area of research and professional activity, and it is fundamental to understand the types and trends of research in this field. The appropriate supplier selection decision is a fundamental strategic process and plays an important role in supply chain management. In the last decade, academic research on sustainability has evolved rapidly in the supply chain literature. However, there has been scant opportunity for the research community to complete a global assessment of sustainable supplier selection activities to date. This paper seeks to address this need by exploring sustainability in supply chain management, developing a sustainable supplier selection framework with a tool for its operationalization to help managers evaluate supplier selection decisions. The proposed model is based on the TOPSIS concept as a multiple criteria decision-making (MCDM) model and is validated through a case study. This research work follows the best-in-class approach to comply with all applicable environmental regulations and laws in the supplier selection process.

6.1 Introduction

Today European and U.S. manufacturers spend an important amount of their revenue to purchase goods and services. This leads to an increase of the relevance of outsourcing decisions and link their decision results to the firm performance. According to the data extracted in June 2017 from Eurostat, the EU’s resource productivity has increased by 41% from 2000 to 2016. This could be the result of outsourcing material-intensive production to other parts of the world. A resource-efficient Europe is one of the flagship initiatives of the Europe 2020 strategy: it supports the shift towards a resource-efficient economy to achieve sustainable growth (Eurostat, 2017). In order to implement a sustainable supply chain strategy in firms, the role of procurement managers is key to introduce a sustainable policy in their firms’ procurement process and develop a framework and process for its operationalization. Many researchers studied the dilemma managers face during the supplier selection phase in the past. However, they failed to consider the social responsibility guidelines summarized at the ISO 26000 released in 2010. The international standard ISO 26000 provides guidance on
understanding, implementing and continuously improving the social responsibility of organizations, which is understood as the impacts of firm’s actions on society and the environment. The ISO 26000 standard is expected to set the norm for social responsibility in the future (ISO 26000, 2010).

Why is sustainable procurement worthwhile for firms? Sustainable procurement strengthens the firm’s reputation, reduces costs and is rewarded by customers. In essence, firms want to (1) manage risks (brand protection, supply chain disruptions, fines and litigations), (2) reduce costs (improve total cost of ownership, reduce over specification, reduce consumption) and (3) increase revenue (product/service differentiation, access to new markets, income from recycling projects) (EcoVadis, 2018). While the traditional external provider selection focuses mainly on criteria such as price, quality, flexibility or delivery performance (Öztürk and Özçelik, 2014), the goal of corporate social responsibility (CSR) is to ensure a sustainable development of the supply chain by increased resource efficiency. In order to implement social responsibility requirements throughout the supply chain process, this thesis introduces the CSR sustainable criteria for the evaluation of external providers. Next, a sustainable external provider selection framework extending the Triple-Bottom-Line (TBL) concept (Elkington, 1994; Jackson et al., 2011) is developed and a multi criteria approach is presented. The TBL model consists of social equity, economic, and environmental factors.

The paper is structured as follows: Firstly, the supplier selection framework with a clear focus on sustainability is developed based on a detailed literature review. In a next step, the case study of the German industrial firm is presented, and the application of the supplier selection framework as well as the supplier selection process is explained and specified. Finally, the consideration of the sustainability criteria in the selection of suppliers is presented based on a specially developed decision matrix.

### 6.2 Development of an external provider selection framework

Due to the increased relevance of sustainable procurement in the last decade, this research has adapted and extended the categorization of five criteria for supplier selection identified by Chen et al. (2006) into six main clusters combined in the developed external provider selection framework. Chen et al. (2006) presented a fuzzy decision-making approach to deal

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3The Triple-Bottom-Line approach is a method for measuring sustainable performance (Elkington 1994; Jackson et al. 2011).
with the supplier selection and evaluation problem based on the TOPSIS concept as a multiple criteria decision-making (MCDM) model. The six main clusters are (1) strategic value, (2) resource position, (3) performance, (4) potential for opportunism, (5) conformance quality; and (6) corporate social responsibility (CSR). Every main cluster is subcategorized into TOP sub-criteria for the corresponding evaluation. Figure 6-1 includes the definition of all main clusters of the framework. For instance, the main cluster CSR combines the following sustainability criteria: (TOP1) Code of conduct (CoC) for suppliers, (TOP2) ISO 14001 – Environmental management system, (TOP3) REACH / RoHS / Conflict minerals reports such as CMRT reports (conflict minerals reporting template), (TOP4) Occupational Health and Safety ISO 45001 and (TOP5) ISO 50001 – Energy Management. The six categories are described in detail in Section 6.4.3. A brainstorming for the research was performed with the current suppliers of the firm from the case study in order to collect further inputs from the field. The questionnaire is elaborated based on the research’s questionnaire from Kannan and Keah-Choon (2002) and is attached in Appendix 9.2.1
Figure 6.1: Sustainable supplier selection framework

Areas and Factors for sustainable supplier selection management (SSSM)

Triggers for SSSM Assessments
- New product or service introduction
- Need for cost or service improvement?
- Need for demand flexibility?
- Need for competitive advantage?
- Need for resources and skills at the organisation?
- Need for proximity to markets?
- Need for delivery or quality improvement?

Strategic value
- Profitability
- Sales growth
- Technical differentiation
- Strategy (multiple/single source strategy)
- Proximity to markets
- Trade Implications
- Demand flexibility
- Macroeconomic and political situation
- Core / non core product or services
- Competitive advantage

Resource position
- Resources / Capabilities available
- Skills and know-how available
- Assets available
- Process maturity
- Support systems
- Technology and manufacturing processes
- Contract manufacturers capability

Performance
- Conversion costs
- Manufacturing flexibility
- Contract costs reduction
- Defects per million / ppm
- Delivery reliability
- Overall equipment effectiveness
- Asset utilization
- Sustainability punctuality

Potential for opportunism
- Information asymmetry
- Flexibility / Seasonal
- Quality defects
- Delivery delays
- Costs increases
- Skills appropriation
- Complexity relationships
- Make evaluation / simple source

Conformance quality
- QM assessment
- Audit result
- Certification compliance
- Willingness for contractual agreements
- Supply chain surveillance
- Appropriation
- Traceability

CSR
- Code of Conduct (CoC)
- Environmental management ISO 14001
- Reach/REACH/Conflict Minerals compliance
- BS OHSAS 18001
- Occupational Health & Safety
- Sustainable supply chain

Possible outcomes
- Buy from external provider (single sourcing)
- Invest to buy from external provider
- Form an alliance
- Multiple sourcing
- Hybrid sourcing
- Redefine or do not make the product

State

Employees

Public NGOs

Norms and Values
Concerns and Interests
Triggers and possible outcomes from the supplier selection process are also integrated in the supplier selection framework. Detailed analyzes regarding these topics follow in the next sections.

### 6.3 Stages of the external provider selection process

Basically, the supplier selection process can be divided into four stages: (1) planning, (2) data collection and analysis, (3) performance evaluation and (4) improvement (see Figure 6-2). The project leader, assigned to the selection process, plans, coordinates and leads activities ensuring to ensure that tasks are accomplished according to the milestones plan to achieve the key milestone dates on time. The project should be documented in a project sheet containing the following points: (1) general information, (2) main objectives, (3) requirements criteria, (4) pairwise comparative evaluation and (5) decision matrix. Points four and five are described in detail in Section 6.4.3.

Figure 6-2. Stages of the external provider selection process

Source: Own source
Phase one – the planning phase – identifies the products or assemblies for analysis, sets the objectives of the selection process as well as the required resources (including the selection of a multidisciplinary team) in accordance with the firm’s strategy. In addition, risks and opportunities are analyzed, discussed and weighed each other. In phase two – data collection and analysis - the interdisciplinary team performs the data collection and analysis, gathering appropriate records and evidences. Workshops are carried out to determine the weighting, assessment and the supplier-related cost calculation. Whereas the weighting of main clusters is assessed through the pairwise tool in workshop 1, the evaluation of the preferred suppliers is performed with the matrix in workshop 2. Finally, suppliers' offers and qualification costs are evaluated in workshop 3. To ensure a holistic performance assessment in phase three – performance evaluation –, past supplier evaluations are integrated and a SWOT analysis of the supplier is carried out on basis of the collected data. The result of phase four is the provision of the project and the preparation of an action plan, weighted according to the order of the potential effectiveness of the individual actions. Besides the derivation of improvement actions, the purpose of the selection process is also to set a clear timeframe and define clear responsibilities for the following implementation.

**6.4 Review of the theoretical models using the case study of a German industrial firm**

Based on an in-firm case study, supplemented by further interviews with individual industry representatives, the practical application of the two previously presented models is analyzed. Whereas the social and environmental categories from the TBL model are adapted into the CSR main cluster, a decision matrix is built based on the TOPSIS model. The data was collected through a variety of surveys in the firm and its external supply chain partners as well as through the analysis of existing documents and a corresponding literature analysis.

**6.4.1 Case study**

The case study is focused on a leading manufacturer of electronical products certified on NEC, CEC, ATEX, GOST, Inmetro and IECEx standards. The firm is a global player based in Germany with 1,788 employees and €286,6 million turnover (key figures from end 2016). The main criteria for the selection of the firm were that the firm had recently made different supplier selection decisions in a wide range of industries and sizes with different kinds of
outcome, namely (1) buy products or services from an external provider, (2) invest to buy from external provider, (3) select a multiple sourcing in order to prevent single source risks, (4) forming a strategic alliance and (5) redesigning or discontinuing products. The case study was conducted to document the decision making process of the firm.

For analyzing the case study multiple sourcing of evidence were used, such as supplier non-disclosure agreements (NDA), confidential disclosure agreements (CDA), supplier self-disclosures, supplier selection assessments, quality assurance agreements (QAA), supplier audit reports, delivery contracts, final reports and project plans. This helped to provide validity and reliability to the case (Yin, 2018). In addition, the case study will be useful to refine the framework and to illustrate how to use this framework in business practice.

The supplier selection process in the case study is limited to two suppliers for strategic reasons. The first supplier is a German global supplier from the EMS (electronic manufacturing services) market with core competencies in customized solutions for product lifecycle management of electronic applications. The supplier is part of a Dutch group which is listed in the Reed Electronics Research report as one of the leading EMS service providers in Europe in 2018 and generated Group-wide €439 million in 2017. The second supplier is from Slovakia and generated – in contrast to the Dutch group – only sales of around €11 million in 2017. The influence of the observed electronics firm on the Slovakian supplier is considerably higher than on the German supplier.

### 6.4.2 Sustainable supplier selection process at the electronics firm

Based on the general supplier selection phase model from Section 6.3, the process is now validated, standardized and further specified in the case study (see Figure 6-3). Sustainable procurement begins with the search and selection of potential suppliers. Following the identification of potential suppliers, the firm requests a self-assessment from the suppliers.
The following defined requirements for suppliers have been agreed internally and are requested and evaluated through the supplier self-assessment questionnaire for each supplier:
1. Does the firm have a certified environmental / occupational health and safety / energy management system according to the standards in Table 6-1?

Table 6-1. Certification matrix

<table>
<thead>
<tr>
<th>Norm</th>
<th>Yes</th>
<th>No</th>
<th>planned</th>
<th>Implemented, however, not certified</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 9001</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>ISO 14001</td>
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<td>EMAS</td>
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<td>ISO 50001</td>
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<tr>
<td>OHSAS 18001</td>
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<tr>
<td>ISO 45001</td>
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</tbody>
</table>

Source: own source

2. Are the principles of the firm approved in accordance with the Supplier CoC?
   ☐ Yes   ☐ No

3. Are the principles of the firm approved in accordance with the Quality Assurance Agreement (QAA) for suppliers?
   ☐ Yes   ☐ No

4. Is the creditworthiness of the supplier confirmed?
   ☐ Yes   ☐ No

As a result of the self-assessment, the suppliers are classified according to the following categories:

- **Fulfilled** (all questions answered with yes)
- **Partially fulfilled** (answering one question with no, creditworthiness, QAA and compliance with the CoC are mandatory)
- **Not fulfilled** (two or more questions answered with no)
At this point, the Supplier CoC of the electronics firm will be discussed in detail in order to emphasize the importance of sustainable aspects. The observed firm has established strict ethical principles for itself, which guide it in its business. In return, suppliers are expected to work according to the same ethical principles. Therefore, the firm has developed a CoC that defines the minimum requirements for a possible business relationship and, as previously discussed, is part of the supplier self-assessment. By signing the CoC, the supplier agrees with the following points:

**Human rights and social standards**
- to comply with the laws of the applicable legal order(s) with respect to human rights and social standards
- to do not disclaim any discrimination, sexual or other personal harassment or a guidance to such behavior
- to respect the personal dignity, privacy and personality rights of each individual
- to promote diversity in its firm
- the employees are free to unite
- to show no tolerance against child labor and forced labor
- to ensure adequate remuneration and to ensure the statutory national minimum wage
- to respect the maximum working time stipulated by law in the respective state

**Safety, health & environmental protection**
- to comply with the laws of the applicable legal order(s) with respect to safety, health and environmental protection
- to protect the environment and conserve its resources
- to pay attention to the safety of its employees and always try to improve it through e.g. trainings

**Corruption and bribery**
- to comply with the laws of the applicable legal order(s) with respect to corruption and bribery
- to pay attention to the competition and antitrust law
- to ensure fair competition and a fair contract design with its business partners
• to do not tolerate any kind of corruption or bribery, which includes any illegal payment offers or other donations to influence a decision

Supply chain
• to use reasonable efforts to promote among its suppliers’ compliance with this CoC

Conflict minerals
• to take reasonable efforts to avoid the use of raw materials which directly or indirectly finance armed groups who violate human rights

Specific quality marks and resp. or certificates can provide the proof of evidence that the supplier complies with the required social and environmental standards.

Once the information received meets or partially meets the minimum requirements for selecting a supplier, a supplier non-disclosure agreement will be requested. Upon receipt of the document, the electronics firm will request a quotation for the parts from the suppliers. In a next step, the firm will respond with an offer, which contains contract terms such as price conditions, lead times and quality requirements. After sending the offers and subsequently agreeing on the terms of the contract with the selected suppliers, the firm conducts a first supplier audit. Here, the minimum requirements of the Supplier CoC and the procurement documents are checked on site.

During the first visit, a quality assurance agreement is presented and discussed with the supplier. After the audit evaluation, an audit report is prepared and corrective actions are addressed. Finally, the results are evaluated using the developed decision matrix and the supplier status is established. The supplier should be added to the internal database as soon as the supplier selection process is released and the supplier qualified. A review report will be created and the supplier will be notified. The firm determines which supplier or suppliers receive a contract and assesses the supplier during the entire contract period to support future supplier selection iterations. The developed decision matrix is described in detail in the next section.

6.4.3 Application of the sustainable supplier selection framework at the electronics firm

The question of this section is how to implement the sustainable supplier selection framework is in the firms’ daily business. The framework model is oriented on the analytic network process (ANP) methodology, a special technique for solving multi-criteria decision problems
by allowing the creation of decision networks, developed by Saaty (1996) and improved by Gencer and Gürpinar (2007). The application of the sustainable supplier selection framework is divided into eight steps: (1) analysis of the external provider problem (trigger), (2) determining the weights of decision makers, (3) determining the goals and criteria and sub-criteria from the framework, (4) determining possible external providers, (5) building the external provider selection model, (6) making the paired comparisons matrices (PCM), (7) building the super matrix with TOPSIS (technique for order preference by similarity to ideal solution) and (8) decision based on the evaluation of the preferred external providers.

**Step 1** – Determine the triggers for the analysis of external provider problems based on the developed framework. Following options are mentioned in the framework: (1) new product or service introduction, (2) need for cost or service improvement, (3) need for demand flexibility, (4) need for competitive advantage, (5) need for resources or skills at the organization, (6) need for proximity to markets, (7) need for delivery or quality improvement.

**Step 2** – Determine the importance weights of the corresponding decision makers (DM). In contrast to the proposed four decision makers defined by Chaharsooghi and Ashrafi, (2014) “(An operations manager (DM1), a financial manager (DM2), a purchasing manager (DM3), and an environmental manager (DM4))”, three decision makers are defined setting their importance weights based on the research of Boran et al. (2009). Whereas DM1 are represented by managers and strategic purchasers (40.6%), DM2 are Research & Development responsible persons, industrial engineers and specialists (23.8%). Finally, DM3 are quality assurance and quality representatives (35.6%). The sum of the weights must be 100%. The novelty of this thesis is the introduction of fix decision makers’ weights for all supplier selection decisions.

At least three decision makers should be integrated into the decision-making process at each level. Supplier selection decisions are thus not made exclusively by purchasing or a specialist department, but by firm-wide cross-functional teams.

**Step 3** – Determine the goals for the supplier selection assessment and determine and customize the criteria and sub-criteria to be weighted at the pairwise comparison matrix. The procedure’s overview is drawn in Figure 6-3. The criteria and sub-criteria are defined in the proposed framework and consider the sustainability criteria from the ISO 26000. Therefore, the CSR main cluster is built up grouping environmental attributes like REACH / RoHS / CMRT Reports, ISO 14001 Certificate effective environmental management system, social
attributes like OHSAS 18001 / ISO 45001 Occupational Health and Safety Assessment, social audit report, Health & Safety plan and Accident Incident Rate Scorecard and organizational and cultural attributes like ethical internal CoC and CoC for suppliers. The goal of an energy management system according to ISO 50001 is the continuous improvement of a firm’s energy-related performance.

Step 4 – Determine possible external providers for a specific subcontracting assessment. Possible external providers can either be new or existing suppliers. In order to obtain the necessary evidence for the subsequent supplier evaluation, supplier self-assessments, supplier surveys and creditworthiness information are obtained and supplier audits are carried out.

Step 5 – The sustainable supplier selection procedure was developed together with the decision makers and released internally at the electronics firm, based on the case study.

Step 6 – Every cluster sub-criteria is pairwise compared concerning their importance towards the before determined main goals following the Thurstone’s Law of comparative Judgment (Li et al, 2001). Decision makers are asked to respond to a series of pairwise comparisons where two criteria elements at a time will be compared in terms of how they contribute to their particular upper level criterion. Also in this step, the consistency of each comparison is checked. The relative importance values are determined with a scale of 0 to 2, where a score of 0 represents less importance than the other criteria, a score of 1 indicates equal importance between the two elements and a score of 2 indicates the extreme importance of one element (row component in the matrix) compared to the other one (column component in the matrix). The weights of every criterion are determined afterwards and will be adapted into the pairwise supplier comparison in the next step.

The paired comparisons method for scaling is implemented to obtain an ordering of the preference of the main clusters based on the comparative judgments of the group of criteria. For instance, the weighting factor of the criterion CSR is calculated as follows: CSR weighting factor = integer ((sum of the mean values of the series of criterion CSR (1; 0.4; 2; 0.4; 1) / maximum value of the column "total") * 10); gives 6 = ((4.8 / 8) * 10) (see Figure 6-4). Subjective estimations and judgements can forward to incongruences as seen by the rating of criteria in the study. However, this method is well-established for researchers and practitioners.
Step 7 – Building the super matrix according to the TOPSIS\textsuperscript{4} method. In the super matrix, the supplier rating is determined by the decision makers on a scale from one to five. A rating of one means that the condition does not meet the requirements, a rating of two means that the requirements are only partially met, a score of three indicates that the requirements are almost completely met, a value of four means that the requirements are fully met, and a value of five indicates that the condition is exemplary (see Figure 6-5). For instance, for the criterion "strategic value", suppliers A and B are rated with four and five points, respectively. The weights of each criterion are taken from the pairwise comparison matrix and inserted into the super matrix. For the criterion "strategic value", the weighting factor is eight. The results of the calculation are rounded off, thus Supplier A receives a score of 4.1 in the category "Strategic Value", which using the weighting factor gives a weighted value of 33 points and finally leads to a total degree of fulfillment of supplier A of 65%.

\textsuperscript{4} The TOPSIS is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon (1981) with further developments by Yoon (1987), and Hwang et al. (1993).
Step 8: Decision based on the preferred supplier rating. For the evaluation of the results, five categories are defined according to the degree of fulfillment:

1. 100% to 80%: high potential (proved and preferred, continuing is recommended)
2. 80% to 60%: intermediate potential (proved, continuing is recommended)
3. 60% to 40%: low potential
4. 40% to 20%: high risk (caution, looking for alternatives)
5. 20% to 0%: does not progress (search for alternatives)

In the following part of the paper, the main clusters of the sustainable supplier selection framework are discussed in detail using the case study. The case study focuses on the described high-tech manufacturing electronics firm, which is looking for a suitable supplier to buy key components for new products. The focus is on the manufacturing of innovative interface and system solutions, which include printed circuit board (PCB) assembly, painting, and the execution of the respective functional and in-circuit tests. The research and development activities of the electronic devices are carried out internally. This product family represents a new product line within the business unit “automation” of the electronics firm.
Triggers
Based on the case study, the main trigger for the supplier selection was the new product introduction and the need to process the project in the required time. The current high demand of electronic manufacturing parts at the global market and the allocation of parts by suppliers makes it difficult to find EMS providers with available capabilities and enough expertise to accept this order. As a result of this, a multidisciplinary team was set up to carry out the supplier selection analysis.

Main clusters of sustainable supplier selection
The goal of the firm is to select a supplier with a high resource position, high profitability, high CSR reputation, low potential for opportunism, preferring the centralized arrangement of the completed processes, services and having qualitative proof for certification bodies.

Strategic value. The selected parts family provides a clear competitive advantage and has a relative high strategic value to the firm because of their technical differentiation against competitors.

Resource position. Whereas the lack of available contract manufacturers at the market with advanced technology and expertise on similar industry are currently an issue, the firm identified a supplier located in Slovakia with available ressources to process and deliver the project within the expected time. Hence, this crucial criteria has the major importance for the supplier selection assessment. In contrast to the Slovakian supplier, the German supplier has lack of resources in its plant which impacts on long delivery times. The potential to deliver this new product to the firm’s customers on time is a clear advantage for the firm against its competitors. Special test adapters and tooling would be required to perform the in-circuit and functional tests at the supplier site. In order to conduct a deep supplier evaluation, an on-site supplier audit was performed by both suppliers on February 26-27th and March 13th (2018) in Germany and Slovakia respectively. Due to special certifications and technical requirements of the parts, a support system and support team would be required.

Performance. The contract cost reduction criteria is relevant, but a high delivery performance was the fundamental criteria for the assessment in the case study. Whereas the evaluation of technology and manufacturing processes by the supplier located in Germany is higher, his current low resource position because of the high market demand makes it difficult to process the project within the firm’s expected time. The sustainability level is higher at the German
supplier compared to the Slovakian supplier, which is verified by certifications and the performed on-site audit. The definition of key performance indicators to monitor the process is essential to evaluate the outcome decision. Contract cost reduction indicators, delivery and quality performance figures and asset utilization were taken into account.

**Potential for opportunism.** While the level of quality by the German supplier is better evaluated, the delivery performance and the flexibility of the Slovakian supplier to deliver the project within the required time is exemplary. The information asymmetry plays an important role by the Slovakian supplier, but not by the German supplier who can communicate in the same language. The risk of an increase of quality defects, purchased costs, delivery delays and a complexity relationship with the external provider were also taken into account. Additionally, surveillance and auditing costs must be required to support the external provider until the process is matured and stable at its site.

**Conformance quality.** After the audit was performed at both suppliers, it was verified that both firms are ISO 9001:2008 and ISO/TS 16949:2009 certified. The German firm was additionally certified complying with the requirements for manufacturers of medical devices ISO 13485:2013. While the willingness for contractual agreements is higher with the Slovakian firm, a supply chain surveillance plan is more consistent and reliable by the German supplier. In contrast to the German supplier who performed six supplier audits in Asia in the last years, the Slovakian supplier prefers mainly supplier statistic evaluations.

**CSR.** As part of the sustainable supplier selection, both suppliers were evaluated with reference to environment, social, ethics and sustainable supply chain aspects. Both suppliers have defined an internal CoC. However, neither of them defined a specific supplier CoC. Both suppliers have a valid and certified environmental management system, which comply with the ISO 14001 requirements. Additionally, the Slovakian firm has granted a certification according to OHSAS 18001 – Occupational Health & Safety requirements. A CSR evaluation criteria is not performed by neither of both suppliers. However, the German supplier has a quality management system (QMS) which takes into account the Global Reporting Initiative (GRI) Standards which are the global standards for sustainability reporting (GRI Report, 2017). Additionally, the group of the German supplier has an internal sustainability policy valid for all firms and employees belonging to the group.
Final outcome

The final decision leads to the selection of the Slovakian provider. A risk assessment for the possible second source option has been evaluated. First, the weight of the specified criteria is calculated. The CSR variables were evaluated by three decision makers to determine the weighting of the criteria in this case study. The alternative with the highest weighted coefficient across all six rating categories is Supplier B with 79 percent of the maximum possible total compared to 65 percent for Supplier A. The calculation of the pairwise comparison matrix for the case study is described in detail in Section 6.4.3, "Step 6". Although both results are within 60 to 80 percent, the takeover for Supplier B was ultimately preferred. The assessment found that the sustainability criteria in practice are important for supplier selection, but it does not have the same relevance as often assigned by the research community (Winter and Lasch 2016).

What is the most important information for firms that want to build and maintain a sustainable supplier selection process? In contrast to previous approaches, a multidisciplinary team has been formed and the assessment has not been solely based on the decision of executives focusing on cost savings, but also on areas of expertise that focus on a strategic perspective and delivery performance of the suppliers. Another key factor that needs to be taken into account is the mindset of continuously learning from earlier approaches to avoid previous mistakes in future supplier selection processes.

6.4.4 Operationalization of sustainable procurement

The success of sustainable procurement is reflected in the goals and success factors of the firm and is mainly fed by the following core tasks of the procurement team:

- Reduction of material costs and additional costs by sustainable global sourcing and negotiation of prices and terms as well as long-term payment terms.
- Avoidance of single sourcing and preference of multiple sourcing strategy.
- Proof of the creditworthiness and suitability of the suppliers.
- Avoiding complaints through setting clear instructions, expectations and reconciliation of quality assurance agreements with suppliers.
- Prevent late deliveries or failures in the contractual regulation of safety stock levels with suppliers on the basis of more accurate forecasts.
- Inventory reduction along the supply chain, reduction of store inventories, short replenishment times, minimization of warehousing and reduction of tied capital.
- Early involvement of suppliers in product development to integrate external expertise and realize the most cost-efficient development processes.
- Reduce product variations through standardization strategies to optimize throughput times, manufacturing costs and availability.
- Classification of suppliers in clearly defined product categories. Thus, similar suppliers can be compared with each other and necessary measures can be derived together.
- The tender documents must contain sustainability requirements to be monitored during the audit. Regular communication about corporate social responsibility activities and the corresponding achievement of goals takes place within the purchasing departments and between purchasing and corporate management.
- Establishment of a Supplier CoC, which fully incorporates the corporate social responsibility values.
- Training of employees in procurement. Corporate social responsibility aspects are reflected in regular mandatory trainings with buyers and suppliers. A dedicated corporate social responsibility module is part of the qualification process for new suppliers. The process of "sustainable procurement" has to be established.

### 6.5 Conclusions, limitations and future research

The research presented in this paper has important implications for theory and practice in the supply chain in general and in procurement management in particular. Past literature reviews provide valuable results, but were based upon the assessment of supplier selection decisions failing to consider the TBL concept in combination with others based on strategic or resource based viewpoints. This paper aims to contribute to the study of sustainable supplier selection in supply chain management through the graphical representation of why and how supplier selections are made. The sustainable supplier selection framework presented in this paper deals with the trends identified in the literature by capturing relevant approaches considered in supplier selection decisions. The aim is to provide a graphical representation of relevant dimensions, which need to be studied when examining external provider selection decisions.

One of the main contributions made by the article consists in the integration of the framework into the proposed sustainable supplier selection model and the use of them in a case study, based on a German firm, to confirm the consistency of the methodology. In contrast to Song et al. (2018), a model was developed that integrates not only environmental aspects but also social aspects in order to fully consider sustainable supplier evaluation criteria.
The framework does not only capture relevant factors to be considered, but also provide a structure to investigate these factors and design a practical decision matrix with a pair wise comparison for the practical operationalization of the framework. In contrast to the Banaeian et al. (2018), a basic model for the external provider selection process has been developed that uniquely integrates supplier classification classes according to the sustainability criteria in order to broaden the knowledge for practitioners and academics in this area (Banaeian et al 2018). This study provides a long-term framework for actions in many policy areas. It aims to increase certainty for investment and innovation and to ensure that all relevant policies take account of resource efficiency in a balanced manner. The supplier selection framework can serve as a guideline to provide managers, practitioners, and academics with a practical solution to resolve external provider selection decisions more structured and consistent. As noted in the case study, a better understanding of the experiences and the potential for improvement should be considered for any future decision. As a result, practitioners can learn from past failures by adapting to future needs and keeping the framework and tool alive through ongoing updates. A variation of the above presented framework is applied in a case study performed at the firm in Germany in April 2019. Four external providers for the manufacturing of PCBA are evaluated, audited and the results of the PCBA Benchmarking are summarized in Appendix 6.7.1 (Figures 6-6, 6-7, 6-8, 6-9 and 6-10).

6.6 References


EcoVadis, Sustainability ratings solution for supply chains. 


### 6.7 Appendix

#### 6.7.1 Appendix: QM Project 1/19: „PCBA Benchmarking„

Figure 6-6. RANKING „PCBA Benchmarking“

<table>
<thead>
<tr>
<th>Rank Range</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-80%</td>
<td>High potential (Approved and preferred; proceed is high recommended).</td>
</tr>
<tr>
<td>80-60%</td>
<td>Medium potential (Approved; proceed is recommended).</td>
</tr>
<tr>
<td>60-40%</td>
<td>Low potential ( Recommend with low risk).</td>
</tr>
<tr>
<td>40-20%</td>
<td>Recommend with high risk (proceed with caution or redefine your approach (search for additional alternatives)).</td>
</tr>
<tr>
<td>20-0%</td>
<td>Do not proceed.</td>
</tr>
</tbody>
</table>

Source: case study April 2019
Figure 6-7. Benchmarking evaluation

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Firm A</th>
<th>Firm B</th>
<th>Firm C</th>
<th>Firm D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant</td>
<td>93437 Furth im Wald</td>
<td>Suhl</td>
<td>Lehesten</td>
<td>Saalfeld</td>
</tr>
<tr>
<td>Foundation</td>
<td>1965</td>
<td>2010</td>
<td>1965</td>
<td>1991</td>
</tr>
<tr>
<td>Legal form</td>
<td>Private AG, unlisted, all shares in family ownership</td>
<td>GmbH</td>
<td>GmbH, member of firm’s corporation (AG)</td>
<td>GmbH</td>
</tr>
<tr>
<td>Production plants</td>
<td>Germany (9 plants)</td>
<td>1</td>
<td>Lehesten + Romania</td>
<td>1</td>
</tr>
<tr>
<td>Total Number of Employees</td>
<td>3,700</td>
<td>100</td>
<td>294</td>
<td>208</td>
</tr>
<tr>
<td>Turnover 2018</td>
<td>€ 1.388 bn</td>
<td>€ 17.2 million</td>
<td>€ 44 million</td>
<td>€ 26.07 million</td>
</tr>
<tr>
<td>Reference customers</td>
<td>ABB, BMW, IBM, Advantest, KUKA</td>
<td>Carl-Zeiss</td>
<td>Miele, Eaton</td>
<td>Carl-Zeiss</td>
</tr>
<tr>
<td>Target markets</td>
<td>Electronics industry, automotive</td>
<td>Electronics industry, safety technology</td>
<td>Automotive, industry, consumer</td>
<td>Electronics industry</td>
</tr>
</tbody>
</table>

Source: case study April 2019

Figure 6-8. PCBA supplier comparison (pairwise comparison)

Source: case study April 2019
Figure 6-9 PCBA supplier comparison (decision matrix)

<table>
<thead>
<tr>
<th>External providers</th>
<th>EVALUATION</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Firm A</td>
<td>Firm B</td>
</tr>
<tr>
<td>Requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strategic value / Business Strategy</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Creditworthiness of the supplier</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Technical differentiation</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Demand flexibility</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Performance</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Contract costs reduction (ROI)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Relationship closeness</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Delivery reliability / Project processing in the required time</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Product supply chain risks / Potential for opportunism</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Quality defects</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Delivery delays</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Costs increase</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Resource position</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Process maturity</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Contract manufacturers capability</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Technology and manufacturing processes</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Conformance quality</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Audit result</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Certification</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Supply chain monitoring</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>CSR (Sustainable procurement) / ISO 26000</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Environmental management ISO 14001</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>REACH/RoHS/ (CMRT)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Occupational Health &amp; Safety / ISO 45001</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Source: case study April 2019
Figure 6-10. PCBA supplier evaluation

<table>
<thead>
<tr>
<th>Supplier comparison</th>
<th>EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Firm A</td>
</tr>
<tr>
<td>Strategic value / Business Strategy</td>
<td>Yes, as part of the corporation.</td>
</tr>
<tr>
<td>Creditworthiness of the supplier</td>
<td>ISO 9001:2015 requirements are not implemented. Test system made in-house, long production time, 11 - 12 weeks.</td>
</tr>
<tr>
<td>Technical differentiation</td>
<td>A prototype line is available; 2 SMT lines in the production.</td>
</tr>
<tr>
<td>Demand flexibility</td>
<td>Performance</td>
</tr>
<tr>
<td></td>
<td>Relationship closeness</td>
</tr>
<tr>
<td></td>
<td>Delivery reliability / Project processing in the required time</td>
</tr>
<tr>
<td></td>
<td>Delivery delays</td>
</tr>
<tr>
<td></td>
<td>Quality defects</td>
</tr>
<tr>
<td></td>
<td>Delivery delays</td>
</tr>
<tr>
<td></td>
<td>Costs increase</td>
</tr>
<tr>
<td></td>
<td>Process maturity</td>
</tr>
<tr>
<td></td>
<td>Certification</td>
</tr>
<tr>
<td></td>
<td>REACH/Toxics (CMR)</td>
</tr>
</tbody>
</table>

Source: case study April 2019
HOW TO EVALUATE SUSTAINABLE SUPPLY CHAIN RISKS? A CASE STUDY FROM THE GERMAN INDUSTRY
7. How to evaluate sustainable supply chain risks? A case study from the German industry (Art. 6)

Abstract:
Outsourcing transactions have been arisen and evolved in the last years and purchase managers want to know how firms can manage risks in a proper way. Supply chain disruptions are one of the most critical issues, which can negatively influence on firm’s performance. Avoiding and mitigating disruptions in the supply chain is one of the main challenges for supply chain managers. The aim of this study is to develop a practicable risk management process based on the guidelines of the ISO 31000 for upstream supply chain risk management linking risk assessment, risk identification, risk analysis, risk evaluation, risk treatment and validate the process empirically through a case study. One finding of this paper is the identification of the ISO 31000, the ISO 9001 and the use of a Failure Mode Effects and Analysis (FMEA) tool to assess sustainable supply chain risks (SSCR) in a structured manner and to outline future research opportunities in SSCRM.

Keywords: sustainable supply chain risk management (SSCRM), ISO 31000, ISO 9001, Failure Mode Effects and Analysis (FMEA), case study
JEL Codes: M11, L23, L24.

7.1 Introduction
What is ISO 31000 (2018) for? What are the benefits for my business? There is a growing need to answer these questions and learn about best practices for supply chain risk management (SCRM). Whereas SCRM helps manufacturers plan for and handle disruptions in the supply chain (VanderBok, Sauter, Bryan and Horan, 2007), sustainable supply chain risk management (SSCRM) research is in its infancy stage. ISO 31000 (2018) is a family of standards relating to risk management codified by the International Organization for Standardization. The purpose of this standard is to provide principles and generic guidelines on risk management and is intended for use by anyone in the firms who manages risks (for internal as well for external processes). ISO 31000 (2018) seeks to provide a universally recognized paradigm for practitioners and firms employing risk management processes. In today’s globalized and highly uncertain business environments, supply chains have become more vulnerable to disruptions. Admittedly, there are an increasing number of risks faced by
firms associated with variable material cost or availability of raw materials. ISO 31000 (2018) is intended to be a guideline for managers to develop a risk management strategy to effectively identify and mitigate risks. However, there is still a need for practitioners to know how to implement this in the practice, integrating sustainable criteria as defined in the ISO 26000 (2010). This standard provides guidance on implementing and improving the social responsibility of organizations, mainly on society and environment.

In order to solve this need, this research has three primary goals: 1) review and update the literature on Sustainable Supply chain risk management (SSCRM), 2) determine whether ISO 31000 (2018) provides understandable guidelines for planning and executing SSCRM and 3) collect evidences of SSCM implementation through a case study in the German industry. The rest of the paper is organized as follows: Section 7.2 provides the literature review on supply chain risk management and proposes, presents and describes a process and a framework from the ISO 3100 (2018). In Section 7.3, the proposed process is validated through a case study and trends from experimental evaluations and analyzes are presented in order to assess the effectiveness and efficiency of the proposed process. Finally, the main conclusions and the topics related to this study which might be researched in the future as well as the limitations are discussed and presented in Section 7.4.

### 7.2 Literature review: SSCRM approach

Behzadi, O’Sullivan, Olsen and Zhang (2018) identified robustness and resilience as two key techniques for managing risks and suggested metrics for measuring them. Admittedly, these two characteristics should be taken into account of every risk assessment framework. According to them, “robustness is an ability to withstand disruption with an acceptable loss of performance, whereas resilience (i.e. contingency plans that reduce time-to-recovery) is the potential to recover quickly from disruptions”. While Curkovic, Scannell, and Wagner (2013) proposed the FMEA (Failure Mode and Effect Analysis) as a tool to evaluate supply chain risk management, Ratnasari, Hisjam and Sutopo (2018) assessed risk management using the house of risk (HOR) method. HOR is a modification between FMEA and HOQ (House of Quality) methods. The model is split in two stages, during the first stage risks and risk causing agents are identified and then the severity and occurrences to calculate the Aggregate Risk Priority value are measured. Hence, robustness is assessed. The second stage is intended to formulate and prioritize actions of risk mitigation and at strengthening the resilience of the firm to reduce the probability of risk agents to occur. Whereas D’Amore, Mocellin, Vianello,
Maschio, and Bezzo (2018) proposed a model for optimising the European carbon capture and sequestration, including societal risk analysis and risk mitigation measures. Rostamzadeh, Ghorabaee, Govindan, Esmaeili, and Nobar (2018) developed an integrated fuzzy TOPSIS-CRITIC approach for the evaluation of sustainable supply chain risk management (SSCRM). For the evaluation of the sustainability aspects, they proposed three categories, mainly: (1) Organizational sustainability, (2) social responsibility, and (3) the environmental sustainability.

Admittedly, the probability of disruption on supply chains differs depending on the adopted sourcing strategy (single source (domestic, foreign) and dual sourcing). Kumar, Basu, and Avittathur (2018) stated that the interplay of three important factors; market potential, relative cost advantage and probability of disruption play an important role in the competitive dynamics. The SCRM field is not new so that many researchers proposed SCRM frameworks in the past (Hallikas, Karvonen, Pulkkinen, Virolainen and Tuominem (2004); Kleindorfer and Saad (2005); Manuj and Mentzer (2008); Tummala and Schoenherr (2011)). However, as already pointed out by Scannell, Curkovic and Wagner (2013), they failed to find a consensus about the basis of SCRM.

Implementation of ISO 31000 (2009) within the supply chain risk management has been reviewed in the past (Scannell, Curkovic and Wagner, 2013). However, after the new release of the ISO 31000 in the year 2018 and the integration of the chapter 6.1 (actions to address risks and opportunities) as part of the ISO 9001, revision 2015, an update in the literature was required. Whereas the ISO 31000 (2018) has a character of guideline and recommendation for the industry, the ISO 9001 (2015) set requirements for them. On the one hand, one of the key changes in the 2015 revision of ISO 9001 is to establish a systematic approach to risk. By taking a risk-based approach, a firm becomes proactive rather than purely reactive, preventing or reducing undesired effects and promoting continual improvement. Preventive action is automatic when a management system is risk-based. ISO 9001 (2015) defines risk as “the effect of uncertainty on an expected result”. This standard uses risk-based thinking to achieve this in the following way:

“Clause 4 – the organization is required to determine its Quality Management System (QMS) processes and to address its risks and opportunities.
-Clause 5 – top management is required to:

✔ Promote awareness of risk-based thinking.
Determine and address risks and opportunities that can affect product/service conformity.

Clause 6 – the organization is required to identify risks and opportunities related to QMS performance and take appropriate actions to address them.

Clause 7 – the organization is required to determine and provide necessary resources (risk is implicit whenever “suitable” or “appropriate” is mentioned).

Clause 8 – the organization is required to manage its operational processes (risk is implicit whenever “suitable” or “appropriate” is mentioned).

Clause 9 – the organization is required to monitor, measure, analyze and evaluate effectiveness of actions taken to address the risks and opportunities.

Clause 10 – the organization is required to correct, prevent or reduce undesired effects and improve the QMS and update risks and opportunities” (ISO 9001, 2015).

On the other hand, the update in that ISO 31000 (2018) provides more strategic guidance than ISO 31000 (2009) and places more emphasis on both the involvement of senior management and the integration of risk management into the organization. ISO 31000 (2018) suggests that effective risk management is characterized by principles, framework and process.

This standard states that managing risk is based on the principles, framework and process so that managing risk is efficient, effective and consistent and the purpose of risk management is the creation and protection of value. The principles of risk management and the framework are interrelated. Risk managers are asked to integrate risk management into the firm in a customized and proportionate manner, employing the framework as a tool to achieve the required integration. The framework is split in five steps mainly: (1) integration; (2) design; (3) implementation; (4) evaluation and (5) improvement. This approach is illustrated in Figure 7-1 and integrates the well-known Deming or PDCA (plan-do-check-act) cycle (Johnson, 2016). The leadership and commitment play an important role within the framework, aligning risk management with the firm’s strategy, objectives and culture.
First, within the integration is established the risk management strategy-framework and the roles and responsibilities. Second, in the design are articulated risk management commitment and allocating resources; and establishing communication and consultation arrangements. Third, an appropriate implementation plan including deadlines is developed within the implementation. Fourth, by the evaluation is measured the framework performance and effectiveness against its purpose, implementation and behaviors. Finally, the suitability, adequacy and effectiveness of the risk management framework are improved.

Risk management should be an integral part of all organizational activities, including procurement (ISO 31000, 2018). The risk management process involves the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk (see Figure 7-2). According to the ISO 31000 (2018), the risk management process is focused on (1) communication and consultation; (2) scope, context and criteria; (3) risk assessment, split into (3.1) risk identification, (3.2) risk analysis and (3.3) risk evaluation; (4) risk treatment; (5) monitoring and review; and (6) recording and reporting.
(1) During the communication and consultation stage different views should be considered when defining risk criteria and evaluating risks. Workshops and regular meetings are appropriate in order to bring different areas of expertise together for each step of the risk management process. (2) Defining the purpose, scope of risk management activities and risk criteria are part of the second stage. (3) Risk assessment describes risks that might help or prevent achievement of objectives and their consequences. These risks include: risk identification, risk analysis, taking into account the level of risk and consequences, and risk evaluation to determine the significance of risk. (4) Risk treatment; designing risk treatment plans explaining how the treatment options will be implemented. (5) Monitoring and review include monitoring the risk management (RM) process and its outcomes, addressing responsibilities accordingly; (6) Recording and reporting entail recording results and providing feedback. After the implementation of the risk management plans, a re-evaluation will be strongly recommended to evaluate the effectiveness of the implemented actions. All proposed stages are drawn in Figure 7-2.

Figure 7-2. Risk management process

Source: adapted from ISO 31000 (2018)
Successful implementation of a risk management initiative is an ongoing process that involves working through the implicated activities on a continuous basis.

### 7.3 Data collection methods: in-firm case study

The in-firm case study was based on the approaches’s information obtained from a leading manufacturer of electrical products certified on NEC, CEC, ATEX, GOST Inmetro and IECEx standards. The firm is a global player based in Germany with 1,788 employees and €286.6 million turnover (Key-Figures from end 2016). The effectiveness and operationalization of the SSCRM process is worldwide present and has a supply chain structure connected with suppliers from all over the world, from domestic suppliers located close to the firm, until suppliers located in US, all around Europe, India, China, South Korea, etc. The main criteria for the selection was that the firm had recently faced raw material supply disruptions and required to develop an efficient and effective SSCRM process in order to proactively prevent possible future shortages. Also, the author has a professional relationship with the analyzed firm. The predefined conceptual framework was validated based on a number of interviews with practitioners and middle-level managers. The interviews, the design of the interviews, the analysis of the transcripts and the incorporation of the findings into the framework are described here. Qualitative data analysis is conducted following the Miles and Huberman (1994) methodology of data reduction, data display and conclusion. This thesis analyzes the SSCRM from the buyer’s perspective as it was done in the past by Cheng, Yip and Yeung (2012) in the Chinese business context. In order to build a robust process for the practical implementation of the SSCRM tool, a case study was required to validate the aforementioned guidelines of ISO 31000 and the requirements of ISO 9001. The case study was carried out using multiple sourcing of evidence such as supplier delivery contracts, supplier audit reports, firm’s internal meetings reports, final reports and project plans. This helped to provide validity and reliability to the case (Yin, 1994 and 2018). The case study will be useful in addition to refining the proposed process and framework, to illustrate how to implement and adapt the process into the firms and how to use the framework in a customized manner.
7.3.1 Findings from the case study

The firm required a standardized SSCRM process all along the different business units and manufacturing locations. However, existed clearly problems with the control of documentation and the way SSCRM approaches were conducted and documented depending on the participants involved. In addition to this, interviewees proposed potential improvements during the different workshops in order to standardize the process. The involvement of a multidisciplinary team was mentioned by all interviewees. A key input collected during the case study analyzed is the need to re-evaluate the effectiveness of the taken SSCRM actions, document changes done in writing and reassess them if proceed. Furthermore, the need for improving the communication all along the firm, defining the criteria for monitoring, reporting and recording is identified in the case study. A series of workshops were planned with the decision makers involved into the supply chain risk management process, so that the process can be evaluated for experienced managers dealing with supply chain risks. Along the process, the firm carries out all the stages proposed in Figure 7-2.

(1) Communication and consultation are conducted through regular meetings and documented in meeting minutes, second party audit reports, etc. The communication and consultation is both internal and external. The project leader or supply chain manager is responsible for providing the required monitoring information and provides interorganizational visibility regarding either the normality or abnormality of supply chain processes related to the fulfilment and delivery of a purchase order on-time. This is supported by Giannakis and Louis (2011). In this case study, risk owners are defined depending on the related material group or business unit. Thus, all suppliers are grouped into defined material groups.

(2) Establishing the scope, context and criteria: Procurement, business unit, material group and risk criteria. Based on approach to SSCRM: the risk mitigation approach could be either proactive or reactive. The different directions in the SCRM field are identified in this case study as proposed by Ghadge, Dani and Kalawsky (2012), mainly: behavioural perceptions in risk management; sustainability factors; risk mitigation through collaboration contracts; visibility and traceability: risk propagation and recovery planning; industry impact; and holistic approach to SCRM.

The decision to choose the right SCR strategy is crucial and is found to be influenced by the behavioural aspect of supply chain managers. Therefore, the decisions are taking in workshops, with trained supply chain managers, considering the following characteristics: A)
Sustainable factors are taken into account as part of the firm’s internal and firm’s supplier code of conduct definition. B) Development of long-term supplier partnerships and strategic alliances become a robust risk mitigation strategy. C) ERP system like SAP which is implemented in the firm provides visibility and traceability in order to proactively monitor possible supply chain risks. D) The replenishment lead time of the products can be set at the firm’s SAP for determine products under the Material Requirements Planning (MRP) in order to improve forecasts data. E) This risk management process should be adapted to the firm’s need and firm’s strategy. F) Product life cycle, quality risks like possible recalls and poor customer service should be considered to SSCRM.

The context was established in one of the firm’s internal QM/Procurement meetings. It was pointed out the need to arrange a serial of workshops to improve the procurement process in general, and the SSCRM process considering the different business units and material groups in particular. The risk category-matrix was defined oriented on the scale’s dimensions probability and impact from Wittmann (2000) and its implementation by Thun and Hoenig (2011) providing three different risk categories: (risk criteria are drawn in Figure 7-3).

a) Green: Risk A; Low Risk-Minor; Risk is acceptable, actions are not required, but possible
b) Yellow: Risk B; Medium Risk; Risk shall be reduced, actions are required
c) Red: Risk C; High Risk; Risk is unacceptable, actions are required.

Figure 7-3. Risk criteria definition

Source: case study
Where Risk A is set for scores between 4 and 12, Risk B between 16 and 64 and Risk C from 80 until 320. The risk is calculated by the combination of the likelihood of occurrence the risk event with the importance of the risk and its consequences determined by a monetary assessment categorized. While the probability is categorized as Unlikely, Very low, Low, Moderate, and High, the risk importance is evaluated according to the following criteria, mainly: Insignificant <= €5000; Low > €5000 and <= €10000; Critical > €10000 and <= €50000; Catastrophic with reversible damage>€50000 and <= €500000; and Catastrophic with irreversible damage> €500000.

(3) Risk assessment, is split into: (3.1) Risk identification

During the first workshop, decision makers were split in two groups and they listed a number of opportunities and risks they face during the whole supply chain process, employing a brainstorming methodology. After the group work, both teams presented their results and a discussion took place.

(3.2) Risk analysis, SWOT-analysis, Ishikawa diagram

In the second workshop, decision makers classified the listed opportunities and risks and grouped the repeated wording using a SWOT-analysis and Ishikawa diagram (see Figure 7-4).

Figure 7-4. Ishikawa diagram

Source: case study
The following questions and topics were answered during the SWOT analysis (see Figure 7-5):

- Which requirements are suitable?
- Regular needs
- Value high demand
- Supply critical needs
- What opportunities are hidden behind the strengths?
- What risks are hidden behind the weaknesses?
- What strengths do you have?
- What are your weaknesses?
- Does firm have the strengths to take advantage of its opportunities?
- Does firm have the strengths to handle risks?
- What risks are exposed because of firm’s weaknesses?

Figure 7-5. SWOT analysis

### SWOT analysis

<table>
<thead>
<tr>
<th>Strengths (highlight these)</th>
<th>Weaknesses (mitigate these)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Good use of purchasing cooperations</td>
<td>1. Lack of resources (too many suppliers to look after)</td>
</tr>
<tr>
<td>2. Qualified and experienced employees</td>
<td>2. Inaccurate shopping forecasts</td>
</tr>
<tr>
<td>3. Efficient deadline monitoring</td>
<td>3. Complex information flow system (A3 message)</td>
</tr>
<tr>
<td>4. Well-structured product groups</td>
<td>4. Much effort master data maintenance</td>
</tr>
<tr>
<td>5. Good cooperation with important suppliers</td>
<td>5. No automated ABs check available</td>
</tr>
<tr>
<td>6.</td>
<td>6. Inaccurate order processing (order documents missing)</td>
</tr>
<tr>
<td>7.</td>
<td>7. Supplier selection process is not stopped</td>
</tr>
<tr>
<td>8.</td>
<td>8. Supplier evaluation system unreliable (care insufficient)</td>
</tr>
<tr>
<td>9.</td>
<td>9. IT system for external communications is often incomprehensible (SAP A3 notification message)</td>
</tr>
<tr>
<td>10.</td>
<td>10. Missing specifications</td>
</tr>
<tr>
<td>11.</td>
<td>11. Lack of foreign cultural knowledge</td>
</tr>
<tr>
<td>12.</td>
<td>12. Outdated IT equipment</td>
</tr>
<tr>
<td>13.</td>
<td>13. Inefficient processes</td>
</tr>
<tr>
<td>15.</td>
<td>15. Late involvement in construction and development</td>
</tr>
</tbody>
</table>
Opportunities-Risks-Analysis

<table>
<thead>
<tr>
<th>Opportunities (exploit these)</th>
<th>Risks (Threats) (defend against these)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. communication</td>
<td>1. dependence</td>
</tr>
<tr>
<td>2. capacity reduction</td>
<td>2. delay in delivery</td>
</tr>
<tr>
<td>3. More effective way of working (low prices)</td>
<td>3. Limited flexibility</td>
</tr>
<tr>
<td>4. More competence</td>
<td>4. Defective goods</td>
</tr>
<tr>
<td>5. cost advantage</td>
<td>5. Supplier does not have sufficient ex-knowledge</td>
</tr>
<tr>
<td>6. development partnership</td>
<td>6. Additional work (missing documents)</td>
</tr>
<tr>
<td>7. Concentration on core competence</td>
<td>7. communication</td>
</tr>
<tr>
<td>8. Long-standing, reliable and competent suppliers</td>
<td>8. Rising commodity prices</td>
</tr>
<tr>
<td>9. General cost pressure on suppliers</td>
<td>9. Purchasing the competition is more globally positioned</td>
</tr>
<tr>
<td>10. Increasing market competence and transparency</td>
<td>10. Exchange rate fluctuations</td>
</tr>
</tbody>
</table>

Source: case study

(3.3) Risk evaluation and re-evaluation with an adapted FMEA

By the third workshop, decision makers evaluated the defined risks using an FMEA and agreed the risk evaluation criteria. The FMEA was adapted, removing the detection criteria from the Risk Priority Number (RPN) evaluation to simplify its utility and is illustrated in Figure 7-6.
<table>
<thead>
<tr>
<th>Risk analysis</th>
<th>Initial</th>
<th>Changed status</th>
<th>possible corrective actions for risk mitigation</th>
<th>Probability</th>
<th>Impact</th>
<th>New RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependency: Single source: Business exit</td>
<td>10</td>
<td>32</td>
<td>Qualify alternative supplier</td>
<td>6</td>
<td>15</td>
<td>56</td>
</tr>
<tr>
<td>Limited flexibility: Lack of capacity planning</td>
<td>9</td>
<td>64</td>
<td>Multi-year contract with price &amp; capacity fixing, Introduction ERP at the supplier, Periodical adjustment of capacity planning</td>
<td>6</td>
<td>4</td>
<td>24</td>
</tr>
<tr>
<td>Creditworthiness of the supplier</td>
<td>2</td>
<td>8</td>
<td>Obtaining bank &amp; credit information, Check balance sheet, Supplier (eg equity ratio)</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Insolvency</td>
<td>2</td>
<td>8</td>
<td>Get alert to suppliers, Emergency plan to work out insolvency</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Shareholder structure (including succession regulation)</td>
<td>4</td>
<td>7</td>
<td>Targeted supplier approach to succession, To give ownership confirmation of the tools</td>
<td>4</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Takeover of supplier (e.g., competitors)</td>
<td>2</td>
<td>9</td>
<td>Contact new owners</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>High manager &amp; manager dependency</td>
<td>2</td>
<td>9</td>
<td>Targeted supplier approach</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Relocations</td>
<td>4</td>
<td>2</td>
<td>Auditing &amp; Supplier self-disclosure</td>
<td>4</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Significance price increase</td>
<td>4</td>
<td>9</td>
<td>Agreement of frame contracts with its price conditions</td>
<td>4</td>
<td>9</td>
<td>32</td>
</tr>
<tr>
<td>Une-sided customer structure (&gt; 50%)</td>
<td>4</td>
<td>4</td>
<td>Own policies, only suppliers with max. 50% per market share</td>
<td>4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>CSR/Child labor / environmental protection</td>
<td>2</td>
<td>9</td>
<td>Supplier declaration on child labor / environmental protection (CoC)</td>
<td>2</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Product liability</td>
<td>4</td>
<td>32</td>
<td>Insurance for product liability</td>
<td>4</td>
<td>32</td>
<td>128</td>
</tr>
<tr>
<td>Defective goods: unsafe manufacturing process [quality]</td>
<td>10</td>
<td>9</td>
<td>Request CAPA plan, Plan supplier audit, Agreement of QAA</td>
<td>10</td>
<td>9</td>
<td>90</td>
</tr>
<tr>
<td>Virus / data protection at the supplier</td>
<td>2</td>
<td>4</td>
<td>Non-disclosure agreement, Monitoring on third party audits</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Currency risk</td>
<td>4</td>
<td>4</td>
<td>Increase safety stocks</td>
<td>4</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>High Total Cost of Ownership (TCO)</td>
<td>4</td>
<td>9</td>
<td>Compensation Agreement, Qualification of a second source</td>
<td>4</td>
<td>9</td>
<td>32</td>
</tr>
<tr>
<td>Production downtime</td>
<td>8</td>
<td>16</td>
<td>Build second source, Safety stock, Schedule resources (emergency management)</td>
<td>8</td>
<td>16</td>
<td>128</td>
</tr>
<tr>
<td>Callback actions</td>
<td>8</td>
<td>16</td>
<td>Liability insurance, Traceability, Compensation Agreement</td>
<td>8</td>
<td>16</td>
<td>128</td>
</tr>
<tr>
<td>Delivery delay: 30% or delivery stop</td>
<td>8</td>
<td>16</td>
<td>Build second source, Safety stock, Schedule resources (emergency management)</td>
<td>8</td>
<td>16</td>
<td>128</td>
</tr>
<tr>
<td>Additional work (missing documents): Specification confusing too much / too little</td>
<td>8</td>
<td>8</td>
<td>Standardize Specifications (Clear)</td>
<td>8</td>
<td>8</td>
<td>64</td>
</tr>
</tbody>
</table>

Source: case study

(4) Risk treatment SSCRM plan

During the fourth workshop, a risk management plan with current and actual risk cases from all different material group categories was created and prioritized by the related risk owner and it was defined to re-evaluate the implemented corrective actions using the new RPN from the FMEA. From the proposed strategies defined by Manuj and Mentzer (2008) (avoidance,
postponement, speculation, hedging, control, sharing/transferring, and security), this research adopts the strategies defined by the Project Risk Management Guide defined by the Washington State Department of Transportation (2018) which are aligned with them, mainly: Avoid, Transfer, Mitigate, Acceptance, Exploit, Share and Enhance. Current risk events for each material group were defined, focusing on the determination of TOP5 risk events. Defined actions with insight into firm’s supplier audit plan for the coming year 2019 were taken into account. SCRM plan is illustrated in Figure 7-7 and 7-8.

(5) **Monitoring and review**, defined KPIs from the firm’s score card are monitored. KPIs are defined and integrated into SAP. Thus, risk managers can review the past and current status of all the products and all qualified suppliers. Non qualified suppliers are removed from the database. Thus, no one in the firm can purchase an order by them. By performing first and second party audits using visual RADAR diagrams or turtle methodology for process specific audits.

(6) **Recording and Reporting meeting minutes**, audit reports, SSCRM reports, recording at firm’s SAP database (vendor master) and/or supplier contract management archive as part of the firm’s sharepoint database.
<table>
<thead>
<tr>
<th>Priority</th>
<th>Status</th>
<th>Risk Type</th>
<th>Date Identified</th>
<th>Risk Event (threat/opportunity)</th>
<th>SMART Column</th>
<th>Risk Trigger</th>
<th>Impact Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Active</td>
<td>Strategic</td>
<td>12.11.2010</td>
<td>Delivery delays</td>
<td></td>
<td>Supplier A's delivery performance doesn't meet/or exceed the committed delivery date by more than 10 days for A2 product groups. No second source is available.</td>
<td>Schedule</td>
</tr>
<tr>
<td>2</td>
<td>Dormant</td>
<td>Strategic</td>
<td>12.11.2010</td>
<td>Deterioration of pricing conditions/terms</td>
<td></td>
<td>Manufacturing costs (H2) will be increased, but product final price cannot be changed.</td>
<td>Budget</td>
</tr>
<tr>
<td>3</td>
<td>Active</td>
<td>Operational</td>
<td>12.11.2010</td>
<td>Material defect</td>
<td></td>
<td>Firm's failure rate costs increased because of additional costs for testing and delays on production and customer's order processing time.</td>
<td>Scope</td>
</tr>
<tr>
<td>4</td>
<td>Active</td>
<td>Strategic</td>
<td>12.11.2010</td>
<td>Material is not available, procurement difficulty</td>
<td>PA66 material is not available. Production cannot be started on-time.</td>
<td>Material is not delivered.</td>
<td>Scope</td>
</tr>
<tr>
<td>5</td>
<td>Dormant</td>
<td>Operational</td>
<td>12.11.2010</td>
<td>Supplier communication problems, supplier misunderstanding</td>
<td>Firm specific requirements are not met by suppliers. Firm's certification could be threatened.</td>
<td>Firm specific requirements are not fulfilled. Required testing is missing, conformity declaration is missing (e.g. product A, product B).</td>
<td>Scope</td>
</tr>
</tbody>
</table>

Source: Case study
Source: Case study

<table>
<thead>
<tr>
<th>Affected Docs/Processes Level 2 process</th>
<th>Qualitative Analysis</th>
<th>Risk Treatment (Response Strategy)</th>
<th>Monitoring and Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity production plan, production stop</td>
<td>High, Catastrophic with irrecoverable damage</td>
<td>Risk Matric</td>
<td>Risk Owner</td>
</tr>
<tr>
<td>Probability</td>
<td>Impact</td>
<td>Risk Matric</td>
<td>Responsible BU AT</td>
</tr>
<tr>
<td>L</td>
<td>B</td>
<td>C</td>
<td>Risk C</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>Impact</td>
<td></td>
</tr>
</tbody>
</table>

**Risk Treatment (Response Strategy):**
- **Avoidance:** Lot size: small-midsize; look for possible suppliers who can rapidly processing orders for AZ product groups (higher revenue and medium complexity). Large lot sizes: look for possible suppliers as second source for AA, BB products (ask for an offer from firms like X).
- **Build up a second source strategy:** Second test station for AA and BB product family have been approved by CEO and they will develop by supplier B.
- **Start claiming compensation costs and CAPA plans for qualified supplier complaints. Considered performing product audits and second party audits for the critical.**
- **Additional materials would be qualified.** The qualification phase takes over 6 months. Currently, there is only one material in the certificate.

**Monitoring and Control:**
- **Completion of Supplier B Relocation expected:** 2/2/2019
- **Last status update:** 10/31/18. Initial cost requests have been approved. A second source will avoid future delivery delays.

<table>
<thead>
<tr>
<th>Material costs increased.</th>
<th>Critical</th>
<th>Probability</th>
<th>Responsible BU AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>L</td>
<td>B</td>
<td>Risk B</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>Impact</td>
<td></td>
</tr>
</tbody>
</table>

**Risk Treatment (Response Strategy):**
- **Build up a second source strategy:** Second test station for AA and BB product family have been approved by CEO and they will develop by supplier B.
- **Start claiming compensation costs and CAPA plans for qualified supplier complaints. Considered performing product audits and second party audits for the critical.**
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- **Completion of Supplier B Relocation expected:** 2/2/2019
- **Last status update:** 10/31/18. Initial cost requests have been approved. A second source will avoid future delivery delays.

<table>
<thead>
<tr>
<th>Internal costs increased.</th>
<th>Low</th>
<th>Probability</th>
<th>Responsible BU AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>L</td>
<td>B</td>
<td>Risk A</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Impact</td>
<td></td>
</tr>
</tbody>
</table>

**Risk Treatment (Response Strategy):**
- **Start claiming compensation costs and CAPA plans for qualified supplier complaints. Considered performing product audits and second party audits for the critical.**
- **Additional materials would be qualified.** The qualification phase takes over 6 months. Currently, there is only one material in the certificate.

**Monitoring and Control:**
- **Completion of Supplier B Relocation expected:** 2/2/2019
- **Last status update:** 10/31/18. Initial cost requests have been approved. A second source will avoid future delivery delays.

<table>
<thead>
<tr>
<th>Internal costs increased.</th>
<th>Critical</th>
<th>Probability</th>
<th>Responsible BU AT</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>L</td>
<td>B</td>
<td>Risk B</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Impact</td>
<td></td>
</tr>
</tbody>
</table>

**Risk Treatment (Response Strategy):**
- **Additional materials would be qualified.** The qualification phase takes over 6 months. Currently, there is only one material in the certificate.
- **Clear definition of firm’s requirements, arrange regular meeting with the supplier (in firm and on-supplier site).**

**Monitoring and Control:**
- **Completion of Supplier B Relocation expected:** 2/2/2019
- **Last status update:** 10/31/18. Initial cost requests have been approved. A second source will avoid future delivery delays.
7.4 Discussion and conclusions

The research results seem to be supported by researchers like Curkovic, Scannell, and Wagner (2013) who proposed the FMEA as a tool for the supply chain risk management evaluation. However, this research considers their proposal only as a part of the entire SSCRM process and not as a sole process. In contrast to the research works of Rostamzadeh et al. (2018), who understood the sustainability concept on supply chain in terms of organizational sustainability, social responsibility and the environmental sustainability, this research proposes the sustainable evaluation of external providers according to the requirements defined at the ISO 9001 (2015) (quality management), ISO 14001 (2015) (environmental management), ISO 50001 (2018) (energy management), ISO 45001 (2018) (occupational health and safety) and guidelines of ISO 26000 (2010) (social responsibility of organizations) certification standards.

Following the past implementation of ISO 31000 within the supply chain risk management from Scannell, Curkovic and Wagner (2013), the SSCRM literature is updated based on the new release of the ISO 31000 in year 2018 focusing on the “leaderships” role and responsibility and highlighting the evaluation of external providers’ corporate social responsibility.

Admittedly, the implementation of the SSCRM process requires the definition of relevant KPIs and monitoring them via a suitable and adapted IT system depending on the firms’ needs. For instance, a case study for reduction Supplier Cost of Poor Quality using six sigma methodology is attached in Appendix 9.3.

The research presented in this paper has important implications for theory and practice in the supply chain in general and in procurement management in particular. Past literature reviews provide valuable results, but an update in the literature was required after the release of the new 31000 standard revision. The findings from the case study support the statement from Tang and Musa (2011) posing that there is a “missing gap and potential in developing quantitative models” to resolve SSCRM decisions in a proper way. While Xanthopoulos, Vlachos, and Iakovou (2012) posed to use a developed disruption risk management framework for different types of disruptions related among others to the supply of raw materials and the distribution system, this research proposes to implement the standardized framework from the ISO 31000 (2018) into specific use cases. Managerial implications were
suggested throughout the discussion section, highlighting the importance of the leadership and the commitment of global supply chain managers. Purchase managers should be trained according to the internal firm’s SSCRM process in order to standardize the evaluation of risks and avoid different behavioural perceptions of risk influenced by the behavioural aspect of purchase managers. They should define and take the SSCRM strategy in workshops following the proposed process and explained and adapted tools. This research seems to be aligned with the need to formulate and prioritize the action of mitigation that the firm should pursue to reduce the probability of risk proposed by D’Amore et al. (2018). Indeed, three risk levels are defined in order to simplify the risk assessment and risk evaluation of possible risk events.

Contrary to past approaches like the research of Kern, Moser, Hartmann, and Moder (2012) who developed a model for upstream supply chain risk management without taking into account the communication, consultation, recording and reporting stage, this thesis states that SSCRM is a process linked to the principles described in the ISO 31000 (2018) and the sustainable guidelines defined in the ISO 26000 (2010) to reduce overall corporate risk by implementing a customized and adapted framework. This study is aimed to map the risks in the German industry and formulate risk mitigation alternatives to mitigate, avoid and prevent the risks. A combination of methods was proposed to select a set of proactive actions depending of the process stage in order to improve the process effectiveness and prevent or reduce supply disruption risks. The proposed SSCRM process will involve a two-stage implementation process: (1) the SSCRM process and (2) the managerial actions required to implement the SSCRM plan.

The systematic approach undertaken will provide future researchers and managers with an insightful understanding of the SSCRM field. Notwithstanding the above findings and contributions, this study faces a number of limitations and so do its outcomes. Firstly, a potential limitation of this study stems from the fact that the in-depth analysis focused exclusively on one case study, located in Germany. As a consequence, the comparison with other case studies from other regions was not evaluated. Secondly, the integration of the ISO 31000 framework and process into the firm showed efficiency in the SSCRM firm’s process, but how is the acceptance of the ISO 31000 in other branches, regions and firms? Do firms find the ISO 31000 adoption understandable and useful?

However, the findings seem to provide a valuable understanding of the current situation in this research field. The present study equally suggests several future research strands which may encourage more intensive studies in this important area. More qualitative research is needed to go deeper into the variety of different sustainable supply chain risks that require
distinct assessment and risk strategies (avoidance, transference, acceptance, exploitation, sharing, enhancement, mitigation, etc.). The proposed SSCRM process sheds light on the effects of upstream supply chain risk management activities on risk performance improvement. However, it would be interesting to investigate what other factors and criteria contribute to upstream sustainable supply chain risk performance. Admittedly, this article can prove useful for researchers and decision makers, since new trends and standards are emerging in both areas that will probably lead to future research and different ways of SSCRM implementation in firms. Hopefully, the present paper will give rise to a new approach to studying SSCRM practices.

7.5 References


Applying Six Sigma for Reduction Supplier Cost of Poor Quality: a case study from a German electronics firm
Abstract:

The Cost of Poor Quality (COPQ) is receiving significant attention from many firms and researchers. In fact, given that outsourcing and materials account for an ever-growing proportion of final product costs, practitioners and researchers have recently started implementing different methods to reduce supplier COPQ. Academic research on the Six Sigma methodology has evolved rapidly in the last decade and, to date, there has been scant opportunity for the research community to analyze it in an in-depth case study. This paper, then, seeks to explore the effects of an application of Six Sigma to reduce supplier quality-related costs in the electronics industry; to that end, the present study adapts the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) framework to help managers evaluate opportunities for improvement, save costs and generate benefits. By means of the Six Sigma methodology, this research article verifies the proposed DMAIC Six Sigma framework through a case study on the supplier complaint process in an electronics firm in Germany. This paper addresses the gap in the literature about Six Sigma and supplier relationships, with a focus on the supplier complaint process, including logistics activities. Furthermore, the company analyzed has a worldwide presence and constitutes a valuable source of information.

Keywords: Cost of Poor Quality, Supplier Quality, Six Sigma, Supplier performance
8.1 Introduction

How can practitioners and researchers improve the efficiency of a process? Firms always seek to improve their processes in order to remain competitive. Ineffective and inefficient processes lead to extra costs for firms that do not contribute to their strategy.

What is Six Sigma? Six Sigma is a statistical method that measures a process in terms of defects, namely how far the process deviates from perfection and how many defects there are in a process. The Sigma scale measures Defects per Million Opportunities (DPMO).

Why is Six Sigma worthwhile for firms? According to Snee (1999), the Six Sigma methodology allows firms to save costs by identifying and eliminating failure causes in processes, focusing on the outcomes that are relevant for their customers (Murumkar, Teli and Loni, 2018). In fact, firms can employ this methodology to get benefits and achieve stable and standardized processes, with a reduction in systematic failures, process variations and defects.

What is Cost of Quality (COQ)? COQ summarizes the total of conformance and non-conformance (COPQ) costs. Whereas COPQ is mainly affected by service and product failures, cost of conformance is understood as the preventive costs needed to avoid poor quality. Costs of conformance, such as first and second party audits costs, monitoring costs and incoming quality inspection costs (Machowski and Dale, 1998; Murumkar, Teli and Loni, 2018). COQ has drawn much attention from the research community in the last decade, with firms and universities focused on the need to save costs. Thus, Zahar, El Barkany and El Biyaali (2015) conducted a research to determine different quality costs in Moroccan water analysis laboratories. However, there are few studies available on the application of methodologies to improve processes and save costs. Despite the interest in Six Sigma, one of the main gaps in current research is that studies have so far failed to consider the relevance of having trained yellow, green and black belts in organizations to positively influence the relationship between Six Sigma practices and performance.

This paper is structured as follows: after the introduction, the next section presents the Six Sigma approach with a literature review. Section 8.3 describes the research design for the case study and explains the operationalization of the proposed framework through the case study. Finally, main conclusions and limitations are identified and discussed in Section 8.4.
8.2 Literature review and Six Sigma approach

8.2.1 Literature review and Six Sigma approach

“Whereas Lean focuses on reducing systematic waste (non-value added processes and procedures) and promotes work standardization and flow, Six Sigma aims to reduce the variation of the processes, its adverse effects and enhances process control” (ISO 18404, 2015) (ASQ, 2019). According to the American Society for Quality (ASQ), Lean Six Sigma is a fact- and data-driven, hybrid methodology of improvement that pursues defect prevention over defect detection. (ASQ, 2019). Given the growing relevance of the Six Sigma methodology in the last decade, this study has adapted the Six Sigma framework. Besides the five DMAIC phases (Define, Measure, Analyze, Improve, Control), this research illustrates the relevance of Black Belts, who are experts tasked with implementing Six Sigma methodologies, leading the effectively of Six Sigma Projects. Six Sigma was introduced by Motorola at its Research Centre in 1987 with a quality goal of 3.4 DPMO, where a defect opportunity is a process failure critical to the customer (Table 9-1). This method is intended to achieve continuous significant improvement by eliminating variations in processes. Whereas 3.4 DPMO represent a Sigma level of 6 with a 99.997% quality level and the lowest percentage of COPQ, at 6.210 DPMO the Sigma level is 4 with a 99.4% quality level and a COPQ amounting to 20% of sales (Murumkar, Teli and Loni, 2018).

Table 8-1.Six Sigma level

<table>
<thead>
<tr>
<th>Sigma level</th>
<th>DPMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>690.000</td>
</tr>
<tr>
<td>2</td>
<td>308.000</td>
</tr>
<tr>
<td>3</td>
<td>66.800</td>
</tr>
<tr>
<td>4</td>
<td>6.210</td>
</tr>
<tr>
<td>5</td>
<td>320</td>
</tr>
<tr>
<td>6</td>
<td>3.4</td>
</tr>
</tbody>
</table>

The main outputs within the DMAIC phases are the following: (1) Define (creating a team and appointing a champion; identifying the process; and defining opportunities for improvement); (2) Measure (collecting proformas and evidences; data on supplier complaints, supplier delivery performance, supplier-related costs, auditing costs, hidden costs, current variables and KPIs); (3) Analyze (analyzing key variables and data); (4) Improve
(implementing solutions; deploying and implementing the project; and getting feedback); (5) Control (creating a training plan and planning for stability); and (6) Measure (measuring benefits). These phases are shown in Figure 8-1 and described in detail in the case study in Section 8.3.1. Researchers like Gaikwad, Teli, Majali and Bhushi (2016) applied the DMAIC framework in different contexts.

Figure 8-1. DMAIC Six Sigma framework

Whereas Gerger and Firuzan (2016) used the Six Sigma methodology as a process improvement technique in a case study in Turkey, Murumkar, Teli and Loni (2018) developed a framework for reducing quality cost, highlighting that the goal of Six Sigma is the reduction of defects, namely COPQ and, especially, the impact of supplier quality related costs. The
present research agrees that it is extremely important to track and evaluate the COPQ attributed to firms’ suppliers.

Laureani and Antony (2017) conducted a literature review about the Leadership and Lean Six Sigma methodologies. Gaikwad et al. (2016) presented an application of Six Sigma in India, and Conger (2015) implemented the Six Sigma methodology for improving an inefficient help desk process. It can be concluded, then, that the relevance of implementing the Six Sigma methodology to convert inefficient and ineffective processes into efficient and effective ones is observed in the literature.

### 8.3 Review of the theoretical framework through a case study on a German industrial firm

In order to develop, adapt and validate the framework, a set of qualitative interviews were undertaken as part of an in-firm case study. Practitioners (product managers, strategic purchasers, production managers, developers and quality managers) were interviewed at a firm located in Germany. Qualitative research was a better fit for the type of questions required for the study. The interviews highlighted the essential importance of practitioners when improving processes at firms. The interviews, the design of the interviews, the analysis of the transcripts and the incorporation of the findings into the study are described here. An analysis of the recent Six Sigma literature was performed and served as the basis for preparing and designing the interviews. From the beginning of the data collection phase, the author started to decide which information was relevant. Qualitative data analysis was conducted following Miles and Huberman’s (1994) methodology, consisting of the following: (1) Data reduction. In this phase, the mass of qualitative data obtained through interview transcripts, observations, notes and so forth was reduced and organized, and non-relevant data was discarded. Data was collected through a set of interviews at the firm, and also by analyzing existing documents and the literature available. (2) Data display. The analysis of mass data was displayed in the form of tables, charts and other graphical formats as an ongoing process by means of the Six Sigma methodological tools. (3) Conclusion. The analysis review was the basis to draw general conclusions, verify and validate the study. Finally, the plausibility and validity of the reviewed data were tested.

#### 8.3.1 Case Study

The case study focused on a leading manufacturer of electronic products certified on NEC, CEC, ATEX, Inmetro and IECEx standards. The firm is a global player based in Germany.
with 1,690 employees and a €280.1m turnover (key figures from the end of 2018). The firm was chosen mainly because of its need to reduce costs of poor quality, especially the costs caused by the high amount of supplier complaints. Besides, the author works for the firm and is Black Belt certified by the American Society for Quality (ASQ). The case study was intended to document the actions identified in the firm’s management review. The research used primary as well as secondary sources. Observations were made during project meetings. Secondary sources consisted of project reports, meeting minutes, scorecards and multiple sources of evidence, such as 8D reports, scorecard data from the firm, supplier complaints, corrective action reports (CAR), supplier non-disclosure agreements (NDA), confidential disclosure agreements (CDA), supplier self-disclosures, supplier selection assessments, quality assurance agreements (QAA), supplier audit reports, delivery contracts, final reports and project plans, all of which enhanced the validity and reliability of the study (Yin, 2018). In addition, the case study was useful to refine the framework and illustrate how to use it in business practice.

**Phase 1 of the DMAIC process - Define**

**Six Sigma Project**

Improvement of supplier performance data by reducing supplier related costs, standardizing processes and enacting continuous improvement.

**Problem Statement**

Lower than expected supplier performance, also described as late deliveries and high supplier quality defects rate per purchase order. This results in chargeability variances with a negative impact on services margins of approximately €500,000 per year.

**Goal Statement: Expected Results – Business Case**

Operational and strategic impact:

Improvement of supplier delivery and quality figures from 1,500 to 1,000 complaints, while maintaining planned fee adjustment.

Hard benefits: €40,000 could be obtained by reducing supplier complaints. Inspection costs and additional testing costs on finding defects are estimated to be an extra €80 per complaint, for instance in complaints from supplier A, approx. 10 defects per month or €60,000 per annum. In the supplier qualification process, selecting the right supplier saves €5,000 per supplier. Cases of wrongly selected suppliers originate extra costs to the firm estimated at over €50,000. These costs can be saved by selecting and evaluating the firm’s suppliers.
through a methodical and structured supplier management process. Corrective action plans are prepared in January 2016 and implemented in February 2016. Benefits are evaluated between 6 and 12 months after the implementation.

**Soft benefits:**
Customer satisfaction can be improved by reducing quality defects, including saving complaints handling time and reducing delivery delays. A team is set up and a champion is appointed. The project plan with the related milestones per category is defined as seen in Figure 8-2.

Figure 8-2. Milestones

<table>
<thead>
<tr>
<th>Define</th>
<th>Measure</th>
<th>Analyze</th>
<th>Improve</th>
<th>Control</th>
</tr>
</thead>
</table>

Source: case study

COPQ is split into internal and external failure costs:

*Internal failure costs* are costs caused by products or services which do not conform to requirements or customer needs and are found before the delivery of products and services to customers; otherwise, they would lead to the customer not being satisfied. Deficiencies are caused by both errors in products and inefficiencies in processes. They include, for instance, costs for: (1) rework; (2) delays; (3) re-designing; (4) shortages; (5) failure analysis; (6) re-testing; and (7) lack of flexibility and adaptability.

*External failure costs* are costs caused by deficiencies found after delivery of products and services to external customers, which lead to customer dissatisfaction. For instance, they include costs related to: (1) complaints; (2) repairing goods and delivering services again; (3) warranties; (4) customers’ ill will; (5) losses due to sales reductions; and (6) environmental and CSR (Corporate Social Responsibility) costs.

COPQ is calculated from the information summarized in the supplier complaints recorded in the firm’s SAP database. Thus, the COPQ from the firm’s production line due to late delivery or defected parts supplied is estimated at €159,000 and shown in Table 8-2. These costs would disappear if there were no deficiencies.
As part of the Define phase of the DMAIC framework, an SIPOC (Suppliers, Inputs, Processes, Outputs, and Customers) tool is chosen to provide an overview and help in defining a new process. An SIPOC is a process improvement tool that summarizes the inputs and outputs of one or more processes and is widely employed in Six Sigma projects, emphasizing the voice of customers and filled from the customer upstream to the supplier (Figure 8-3).

### Table 8-2. Estimation of supplier-related COPQ

<table>
<thead>
<tr>
<th>Defect</th>
<th>Consequence</th>
<th>Cost / Effect</th>
<th>Frequency</th>
<th>Net Cost</th>
<th>Cost / defect</th>
<th>Lost revenue per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality assurance from program</td>
<td>6</td>
<td>2</td>
<td>12.00 €</td>
<td>106.00 €</td>
<td></td>
<td>1500</td>
</tr>
<tr>
<td>Scheduling</td>
<td>3</td>
<td>2</td>
<td>6.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-work</td>
<td>11</td>
<td>2</td>
<td>22.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logistic costs</td>
<td>4</td>
<td>1</td>
<td>4.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lost production and administrative costs</td>
<td>40</td>
<td>1</td>
<td>40.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Documenting and reporting</td>
<td>10</td>
<td>1</td>
<td>10.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Customer and supplier contact</td>
<td>6</td>
<td>2</td>
<td>12.00 €</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: case study ("Q2-Meldungen")-suppliers-line rejection

Source: case study
Additionally, after a brainstorming session, the process map shown in Figure 8-4 is drawn up. The process map illustrates the relevance of delivering failure-free parts at the firm’s incoming area on time. Otherwise, delivered parts are returned to the supplier and a supplier complaint must be recorded in the SAP database.

Figure 8-4. Detailed Process Map

Phase 2 of the DMAIC process - Measure
As part of the Measure phase relevant questions are formulated, especially:

- How many suppliers are neither selected nor evaluated correctly?
- What is the total COPQ related to supplier-related incidents like non-delivery and logistic delays, shortages or failure-related costs?
- How many supplier complaints and customer complaints originated by supplier-related failures have been filed?
- What is the total cost of supplier complaints?
- Does the firm have second source suppliers for relevant products?
- Which is the supplier failure rate of the previous twelve months?
A data collection plan is created about information sources, possible KPIs (Key Performance Indicators) and those who can provide that information at the firm. The data collection plan is shown in Table 8-3.

Table 8-3. Data collection plan

<table>
<thead>
<tr>
<th>Measure</th>
<th>Definition</th>
<th>Who</th>
<th>Where</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of suppliers not qualified correctly</td>
<td>Suppliers that are neither selected nor evaluate correctly.</td>
<td>Quality Assurance (QA)</td>
<td>SAP Database</td>
<td>All current suppliers</td>
</tr>
<tr>
<td>€ revenue shortfall due to not delivery on time, call-back actions and stop productions</td>
<td>Estimated revenue that was lost due to not delivery on time to the customer, extra rework costs and stop productions extra costs.</td>
<td>QA</td>
<td>SAP Database</td>
<td>Year to date</td>
</tr>
<tr>
<td>No. of supplier complaints</td>
<td>What is the year to date number of supplier complaints we incurred.</td>
<td>QA</td>
<td>SAP Database</td>
<td>Year to date</td>
</tr>
<tr>
<td>Back charge cost</td>
<td>Total Charges that the customer billed the firm back, including the penalisation costs for late deliveries.</td>
<td>Sales department</td>
<td>SAP Database</td>
<td>All the back charges, year to date</td>
</tr>
<tr>
<td>Supplier complaints reason codes</td>
<td>A categorization of the errors which are easily accessed in a database.</td>
<td>QA</td>
<td>SAP Database</td>
<td>All the back charges, year to date</td>
</tr>
<tr>
<td>Initial sampling process and differences of the specification by supplier evaluation process</td>
<td>Has the poor execution initial sampling process and deviation by the supplier evaluation figures all along different plants</td>
<td>Purchase department</td>
<td>SAP, BI Database</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

Source: case study

Validating the measurement system

- Testing supplier KPIs in terms of on-time deliveries and number of quality defects
- Evaluating supplier assessment sheets and number of qualified and non-qualified supplier complaints
- Comparing several suppliers belonging to the same supplier material group for repeatability failures
- Comparing several suppliers belonging to the same supplier material group for accuracy

Measuring baseline performance

Performance is measured by evaluating the extent to which the target of the project has been reached, as described below:

**CURRENT May 2015**
- COPQ: €159,000
- No. of complaints (Q2): 1,538
- Supplier failure rate: 2.22%
- Sigma level: not measurable
- DPMO: not measurable

**GOAL May 2016**
- COPQ: €130,000
- No. of complaints (Q2): 1,200
- Supplier failure rate: 1.05%
- Sigma level: 2
- DPMO: 10,106
A Pareto diagram of the suppliers having filed the most complaints for the 12-month period going from June 2014 to June 2015 is created and shown in Figure 8-5.

Figure 8-5. Pareto diagram: Top 10 suppliers by number of complaints

The Pareto diagram shows that supplier A accounts for a considerable proportion of the total COPQ. Therefore, this study investigates the main failures and root causes related to that supplier. Supplier A is a manufacturer of electrification products, especially low voltage circuit breakers.

The top issues and critical failures for supplier A are investigated and summarized as follows:

<table>
<thead>
<tr>
<th>Top issues for supplier A</th>
<th>Top root causes for supplier A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latching issue in combination with AUX</td>
<td>FI-Wrong setup of the AC tripping current</td>
</tr>
<tr>
<td>Latching issue without AUX</td>
<td>Incorrect adjustment of molding tool</td>
</tr>
<tr>
<td>FI trip out of tolerance</td>
<td>Length of mounted F-part out of specification</td>
</tr>
<tr>
<td>FI test button does not trip</td>
<td>Welding electrode got worn</td>
</tr>
<tr>
<td>FI test button clamped</td>
<td>Assembly failure</td>
</tr>
<tr>
<td>Continuity issue</td>
<td>Incorrect tampoprint</td>
</tr>
<tr>
<td>TELE U (under voltage CB) defect</td>
<td>Connection axle bent</td>
</tr>
<tr>
<td>Auxiliary contact (AUX) failure, CA-CB</td>
<td>Screw torque incorrectly applied</td>
</tr>
<tr>
<td>Assembly failure</td>
<td>Tele L coupling damaged</td>
</tr>
<tr>
<td></td>
<td>Relay pin damaged</td>
</tr>
<tr>
<td></td>
<td>Ceramic cover plate cracked</td>
</tr>
<tr>
<td></td>
<td>Wrong screw used on terminal 4</td>
</tr>
</tbody>
</table>
Phase 3 of the DMAIC process - Analyze

Potential Xs – Theories to be tested are listed below:

X1: Supplier management process is outdated and unclear
X2: Employees are not trained according to ISO 9001 standards
X3: Implemented failure delivery rate definition deviates from firm’s defined scorecard values
X4: Incomplete or missing failure description in the firm’s complaint system
X5: Extra costs due to related supplier failure costs are not charged to suppliers
X6: Supplier selection process is unclear and not standardized; decision makers other than purchasers are missing
X7: High amount of repeated failures because of the inefficiency of implemented corrective actions
X8: Procurement process is unclear / confirmation orders are not read
X9: Defects caused by lack of training and awareness

Cause-and-effect diagram on vital few categories

As part of the analysis phase, an Ishikawa diagram (also called fishbone diagram) is employed. This cause-and-effect diagram was created by Ishikawa (1968) to develop a tool illustrating the causes and effects of a specific event. The output of “high supplier-related costs” is due mainly to an unclear and inefficient supplier complaint process and a lack of employee training. Further potential factors causing the overall high supplier-related COPQ are identified. Each cause for imperfection is a source of variation, which is usually categorized into major clusters to identify and classify the variation sources.

Summary results of theories tested

X1: Supplier management process is outdated and unclear- TRUE
X2: Employees are not trained according to ISO 9001 standards- TRUE
X3: Implemented failure delivery rate definition deviates from firm’s defined scorecard values- TRUE
X4: Incomplete or missing failure description in the firm complaint system- TRUE
X5: Extra costs due to related supplier failure costs are not charged to suppliers- TRUE
X6: Supplier selection process is unclear and not standardized, decision makers, others than purchasers are missing - TRUE
X7: There is a high amount of repeated failures because of the inefficiency of implemented corrective actions- TRUE
X8: The procurement process is unclear / confirmation orders are not read- TRUE
$X_9$: The lack of training and awareness cause defects- **TRUE**

Vital few Xs on Supplier performance

$Y = f(x_1, x_3, x_5, x_7, x_8, x_9)$

Vital few Xs are:

-- $X_1$ – Process outdated
-- $X_3$ – KPIs unclear
-- $X_5$ – Supplier complaints costs not charged
-- $X_7$ – Wrong supplier selected
-- $X_8$ – Responsibilities unclear
-- $X_9$ – Employees not trained

Finally, an FMEA (Failure Mode and Effects Analysis) tool is used in the analysis phase to determine which actions have more influence on COPQ. As illustrated in Table 8-4, the supplier quality complaint process is the most influential action, with the major Risk Priority Number [RPN] of 512. RPN is used when assessing risk to help identify critical failure modes associated with the process. The FMEA tool is widely used in the electronics industry. This Table illustrates the potential failure effects and the evaluation of related risks according to their RPN, which is calculated for each failure mode by multiplying Severity (the effect of a failure), Occurrence (likelihood of occurrence) and Detection (effectiveness of the controls to prevent or detect the cause). Tested theories are listed in the “Process step” column of the FMEA.
<table>
<thead>
<tr>
<th>Process step</th>
<th>Key process input</th>
<th>Potential failure mode</th>
<th>Potential failure effects</th>
<th>SEV</th>
<th>Potential causes</th>
<th>OCC</th>
<th>Current process controls</th>
<th>DET</th>
<th>RPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the process step?</td>
<td>What are the Key Process Inputs?</td>
<td>In what ways can Key Inputs go wrong? (Process fails to meet requirements)</td>
<td>What is the impact on the Key Output Variables (customer requirements) or internal requirements?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplier related costs from late delivery performance, rework costs or complaints are not monitored.</td>
<td>SOP for the reporting plan and follow-up by the supervision department.</td>
<td>CFS rep. does not monitor accounts on a timely basis, no SOP in place to set time frames for notification.</td>
<td>Money is not collected on a timely basis, affecting cash flow and profitability. There is no requirement from Firm to charge rework costs to Firm suppliers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New suppliers are selected by purchase department without previous agreement with quality department. A risk management plan is not in place and only costs figures will be evaluated.</td>
<td>SOP for the supplier selection, supplier assessment sheet, reporting plan and follow-up by supervision.</td>
<td>Supplier assessment sheet is not implemented and therefore there is no evaluation in place. Purchase department evaluates the new supplier based on part costs reduction and not considering possible relevant quality issues.</td>
<td>Customer satisfaction is lowered. Unnecessary time and effort by supplier quality team and incoming quality inspectors is spent following up on late payments.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Supplier evaluation process to reflect supplier performances

- SOP for the supplier evaluation process, reporting plan and follow-up by supervision.
- ABC-Analysis, Q-figures, delivery performances

Different statistical definitions implemented across the Firm business units

Customer satisfaction is lowered. Evaluated supplier figures are not transparent and unnecessary time and effort is spent following up on amounts not past due.

8

This process has not been reviewed on a regular basis to reflect the current customer and Firm production needs

8

None

7

448

Phase 4 of the DMAIC process - Improve

Solutions for proven Xs (Table 8-5)

X1: Updating the supplier complaint process in ViFlow management system.

X3: Updating the firm’s definition of KPIs and standardizing them throughout the process.

X5: Updating compensation agreements with supplier to refund qualified supplier complaints.

X9: Training employees involved focusing on relevant skills according to the updated process.

Table 8-5. Solutions for proven Xs

<table>
<thead>
<tr>
<th>Solution</th>
<th>X1</th>
<th>X2</th>
<th>X3</th>
<th>X4</th>
<th>X5</th>
<th>X6</th>
<th>X7</th>
<th>X8</th>
<th>X9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving and updating the supplier complaint management process</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arranging in-house training for all employees involved</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redefining KPIs (definition of supplier delivery rate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Initiating a process for updating supplier compensation agreements</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigating root cause of repeated failures</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-evaluating critical suppliers and creating a second source plan</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: case study

The analysis confirms that the supplier complaint process is the key to improving supplier performance and saving supplier-related COPQ. Therefore, the process is created, released and published through the firm’s ViFlow management system as shown in Figure 8-6.
A reworking sub-process is created within the supplier complaint process, also defining all the steps to follow and the required documentation. This sub-process is illustrated in Figure 8-7. For instance, the supplier complaint coding’s definition is set up at the SAP database and drawn in Figure 8-12 of Appendix 8.6. 

Source: case study
The prioritization of supplier complaints is shown in Figure 8-8 as a sub-process and includes four priority levels, described below:

Priority 1 is intended for safety-relevant failures; failures which can lead to shortages, production stops, customer recalls, human damages, extremely long delivery delays and internal costs with a COPQ estimated at over €1,000.

For these cases, the firm has defined the following expected reaction plans and actions for suppliers:

Within 24 hours on working days:
- Presence of a qualified representative of the supplier on site
- Initial containment actions / determination and limitation of damage
- Initiation of failure analyses of the defected products
- Provision of error-free products (replacement delivery)
- Request and monitoring of 3D/8D reports

8D reports must be created within 10 working days.

Priority 2 refers to failures classified as repeated errors and error costs, which can lead to shortages and production stops with a total COPQ lower than €1,000. For these cases, the firm has defined the following expected reaction plans for suppliers:

Within 48 hours on working days:
- Determination of error, damage limitation
- Initiate failure analyses of the defected products
- Provision of error-free products (replacement delivery)
- Request and monitor 3D/8D-Reports

8D-Reports must be created within 10 working days.

Figure 8-8. Sub-process - Complaint Process Flow

Priority 3 is intended for minor failures with a total COPQ of between €100 and €500, which can lead to minor production rescheduling, delays and extra administrative costs. The following expected actions from suppliers are defined at the firm. Within 48 hours on working days:
- Request and monitoring of a supplier statement or a 3D report

The expected reaction time for the statement or the 3D report is 10 working days.

Priority 4 is intended for minor failures with a total COPQ lower than €100, which can lead to extra administrative costs. These are typical failures like damaged packaging or labels or minor optical failures, as well as missing or wrong delivery notes or shipment documents that must be resent.
- Request and monitoring of a supplier statement
The expected reaction time for the statement is 10 working days.

An implementation plan is shown in Figure 8-9.

**Figure 8-9. Implementation plan**

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
<th>Resource</th>
<th>Task Status (G/Y/R)</th>
<th>Start Date</th>
<th>Finish Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting agreement on proposal</td>
<td>Meeting with management of business units B and F as well as representatives from the project management group to get agreement on proposal and set a start date for implementing recommendation.</td>
<td>Purchase leader</td>
<td>G</td>
<td>15/03/15</td>
<td>01/04/15</td>
</tr>
<tr>
<td>Discussing tools and guidelines</td>
<td>Meeting with project management group to discuss what types of feedback questions are asked currently. Writing up a guidance document that may contain possible feedback questions and data analysis examples.</td>
<td>Purchase leader</td>
<td>G</td>
<td>01/06/15</td>
<td>01/07/15</td>
</tr>
<tr>
<td>Communicating system</td>
<td>Communicate to business units and upper management on new feedback rule.</td>
<td>Purchase leader</td>
<td>G</td>
<td>01/06/15</td>
<td>01/10/15</td>
</tr>
<tr>
<td>Monitoring effectiveness</td>
<td>Obtaining feedback on next business process change to test whether the feedback loop helped in the implementation process.</td>
<td>Error proofing team</td>
<td>G</td>
<td>15/07/16</td>
<td>11/11/16</td>
</tr>
</tbody>
</table>

Source: case study

**Phase 5 of the DMAIC process - Control**

After the project is implemented, the process is created and the employees are trained according to the new process and the updated documentation. Then, the process is evaluated again; a constant reduction in the number of supplier complaints is observed throughout the following period (Figure 8-10).
In fact, after the implementation of the project, the DPMO value, calculated from data from the firm’s SAP database and Eq. 9-3, greatly improved.

\[
DPMO = \frac{\text{Number of defects} \times 1,000,000}{((\text{Number of defect opportunities/Unit}) \times \text{Number of units})}
\]

Figure 8-11 shows the results from the beginning to the end of the Six Sigma project. Thus, 1,355,730 defects out of 63,587,427 opportunities and three defect opportunities per unit provides a DPMO of 7,106.908 and a Sigma level of 4.

Figure 8-11. Project results

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>COPQ: €159,000</td>
<td>COPQ: €130,000</td>
<td>COPQ: €100,000 / €70,000 reimbursed from Supplier</td>
</tr>
<tr>
<td>No. of complaints Q2: 1538</td>
<td>No. of complaints Q2: 1200</td>
<td>No. of complaints Q2: 1084</td>
</tr>
<tr>
<td>Supplier failure rate: 2.22%</td>
<td>Supplier failure rate: 1.05%</td>
<td>Supplier failure rate: 0.66%</td>
</tr>
<tr>
<td>Sigma level: not measurable</td>
<td>Sigma level: 2</td>
<td>Sigma level: 4</td>
</tr>
<tr>
<td>DPMO: not measurable</td>
<td>DPMO: 10,106</td>
<td>DPMO: 7,106</td>
</tr>
</tbody>
</table>
8.4 Discussion and conclusion

Below is a summary of the lessons learned from the Six Sigma project:

• Too many on a team makes it difficult to schedule meetings, it should have fewer than five members.
• Data should be verified early, otherwise, there might be delays later on in the project and the team might lose focus.
• It is difficult for green belts to devote 25% of their working hours to the project if their overall workload is not reduced
• A green belt should be in control of the process.
• Excellence will help a company secure the support needed to improve and implement new changes

The research presented in this paper has significant theoretical and practical implications in supply chain management in general and logistics and outsourcing management in particular. It has often been claimed in recent years that further studies were needed on the operationalization of the Six Sigma methodology to improve the COPQ related to external providers. This paper advances a framework for reducing supplier-related COPQ by improving and standardizing the supplier complaint process in a firm. The project validates the effectiveness and efficiency of the DMAIC methodology as a framework that has been demonstrated to help organizations identify various initiatives for optimal reduction of quality costs. Even though Six Sigma is more widely accepted in many organizations nowadays, in-depth case studies on this methodology are still scarce. The firm analyzed decided to reduce quality cost and improve supplier-related processes using Six Sigma methodologies to achieve manufacturing excellence, which is essential if one is to survive in the global competitive market. In contrast to the Lean methodology and its Just in Time (JIT) principles, employed in the framework proposed by Nimeh, Abdallah and Sweis (2018), the replenishment time for specific products of many firms is even longer than 40 calendar weeks; therefore, the firm signed consignment stock agreements with those suppliers for improving delivery performance and reducing logistics time. In other words, the firm made a strategic decision to improve customer satisfaction and gain new customer orders by ensuring fast delivery performances.

The results of the present article highlight the relevance of building cross-functional teams for achieving continuous improvement (Gutierrez-Gutierrez, L., Leeuw, S. Dubbers, R., 2016)
and implementing suitable and proven tools as needed. This study, for instance, implements the FMEA, SIPOC and process mapping tools, among others. Practitioners and researchers want to know which methodology best fit for a certain process improvement. In fact, KVP (Kaizen), Lean (PDCA) and Six Sigma (DMAIC/DMADV) methodologies can be applied for the improvement of processes. One of the main selection criteria relies on the scope’s grade. Whereas KVP is preferred for small scopes with a low grade of difficulty, Lean is applied primarily for scopes as part of processes with few interfaces and medium grade of difficulty. Finally, Six Sigma is the most suitable methodology for scopes with a high grade of difficulty or problems involving cross-functional processes. Therefore, the applied Six Sigma methodology suited with the initial problem statement. This study identifies the need to subcategorize the term COPQ in three categories: (1) Supplier related failure costs (SCOPQ); (2) Internal related failure costs (ICOPQ); and (3) Customer related failure costs (CCOPQ).

SCOPQ is defined as the costs associated with defects and deficiencies originated by suppliers. For instance, they could include the costs for: supplier-related incidents like non-delivery and logistic delays, shortages or failure-related costs, monitoring costs, production stop costs, rework costs, complaints, administrative costs, etc. This research not only validates the proposed framework through an in-firm case study, but also confirms the relevance of mitigating and avoiding biases and recommends standardizing processes and regularly training the employees involved. Unlike Gaikwad, Teli, Majali and Bhushi (2016), this study uses an FMEA tool to evaluate risks and prioritize an action plan in order to obtain greater benefits during the analysis phase. In fact, one of the aims of this research is to reduce COPQ by standardizing the supplier complaint process and training the employees involved. Thus, Six Sigma strategies seek to improve output quality in a process by identifying and removing the causes of defects and minimizing variability in manufacturing and business processes, thus obtaining long-term improvements across the organization. In line with Murumkar, Teli and Loni (2018), the findings of this study emphasize the importance of tracking and evaluating the COPQ attributed to firms’ suppliers. According to their framework for quality cost reduction, however, Six Sigma is aimed at reducing defects, with a focus on COPQ and the impact of supplier related quality costs; instead, the present research project shows how Six Sigma can be applied to reduce supplier quality cost and proves its efficiency through a case study in the German electronics industry. Moreover, this Six Sigma project was developed as part of the author’s MBB certification (Appendix 10.1.7).
Notwithstanding the above findings and contributions, this study faces a number of limitations and so do its outcomes. Firstly, a potential limitation of this study stems from the fact that the in-depth analysis focuses exclusively on one case study, without comparing it to other case studies. Secondly, the proposed framework was applied in the electronics industry in Germany; therefore, its application to different sectors, branches and regions can be addressed. However, the findings from this study seem to provide a valuable understanding of the current situation in this research field. The present paper equally suggests several future research strands, which may encourage more intensive studies in this important area. Researchers can develop the proposed framework by integrating additional criteria for evaluating and prioritizing scenarios to reduce supplier-related COPQ and enhance the efficiency of the approach.

### 8.5 References


### 8.6 Appendix

Figure 8-12. Supplier complaint coding’s definition

<table>
<thead>
<tr>
<th>Coding</th>
<th>Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>KMS-S001</td>
<td>Supplier’s information</td>
</tr>
<tr>
<td></td>
<td>S001</td>
</tr>
<tr>
<td></td>
<td>S002</td>
</tr>
<tr>
<td></td>
<td>S003</td>
</tr>
<tr>
<td></td>
<td>S004</td>
</tr>
<tr>
<td></td>
<td>S005</td>
</tr>
<tr>
<td>KMS-2009</td>
<td>Others</td>
</tr>
<tr>
<td></td>
<td>Z001</td>
</tr>
<tr>
<td></td>
<td>Z002</td>
</tr>
<tr>
<td></td>
<td>Z999</td>
</tr>
</tbody>
</table>

Source: case study
CONCLUSION AND IMPLICATIONS
9. Conclusiones e implicaciones

En conclusión, esta investigación conceptualiza el apoyo a las decisiones de SSM y SCM como competencia de las empresas para aprovechar las decisiones internas y externas y así respaldar sus procesos de compras de manera eficiente. También examina los roles de los tomadores de decisiones y su influencia en el rendimiento de las empresas. Basado en un estudio de caso en una empresa de electrónica en Alemania, este estudio presenta mecanismos y vías a través de los cuales se pueden tomar decisiones de fabricación y compras estratégicas de manera estructurada y eficiente: (1) presenta un modelo desarrollado con sus marcos correspondientes, que permite a tomadores de decisiones, profesionales e investigadores desarrollar capacidades dinámicas; y (2) explica cómo las capacidades dinámicas habilitadas por los profesionales brindan el conocimiento para tomar decisiones en los campos de SSM y SCM de una manera efectiva y eficiente, de modo que las transacciones exitosas creen un valor de negocio añadido para las empresas. La formación de capacidades dinámicas habilitadas en las áreas de SSM y SCM se considera un factor importante para el rendimiento competitivo. Así mismo, la efectividad y eficiencia de la metodología Six Sigma para la mejora de procesos en las áreas de SSM y SCM han quedado demostradas con los resultados obtenidos en el capítulo 8.

9.1 Contribuciones de la tesis

Las contribuciones de esta tesis, presentadas en términos empíricos, teóricos y académicos, se estructuran de acuerdo con las tres fases principales de investigación de la tesis: la revisión de la literatura, la investigación empírica y el diseño de los modelos de decisión en las áreas de SSM, SCM y Six Sigma, haciendo referencia también a los capítulos de la tesis (2-8).

9.1.1 Contribución empírica e implicaciones para la práctica empresarial

A pesar de la gran cantidad de herramientas existentes para tomar decisiones en las áreas de SSM y SCM en las empresas, todavía son escasos los estudios empíricos y su práctica empresarial relativos a la implementación de los criterios de sostenibilidad y las pautas de evaluación de riesgos, conforme con las normativas ISO 26000 e ISO 31000 respectivamente. Mientras que las decisiones en el campo de SSM se refieren principalmente a las opciones de fabricación interna (internalización) y subcontratación, las decisiones de SCM sólo están relacionadas con los procesos de compras.
Sin embargo, a pesar de la relevancia y el potencial de los campos de SSM y SCM para las actividades comerciales, el trabajo empírico debe actualizarse continuamente para responder a los rápidos cambios en términos de factores ambientales, como las constelaciones normativas y políticas, la situación del mercado, etc.

Debido al constante cambio del entorno, las empresas deben reforzar su capacidad para adaptar sus procesos a posibles cambios, especialmente considerando el papel estratégico que desempeña el área de SSM en el rendimiento de las empresas. Los resultados de esta investigación están influenciados por esos cambios debido a los problemas de asignación (allocation) actuales, que causan importantes retrasos en la entrega de componentes electrónicos en todo el mundo. La presente investigación doctoral trata de responder a esta escasez mediante el desarrollo de un conjunto de marcos para apoyar a los tomadores de decisiones y responsables en la toma de decisiones en los campos de SSM y SCM. Adicionalmente, esta tesis trata de verificar la efectividad y eficiencia de la metodología Six Sigma para mejorar procesos en el mundo empresarial.

Después de revisar la literatura de fabricación o compra en el capítulo 2, los principales hallazgos de la literatura se describen, y se enumeran los atributos clave para mejorar la relación con proveedores externos. En el capítulo 3 se desarrolla un marco para ayudar a los responsables a evaluar las decisiones de fabricación o compra. Este marco se verifica y valida en un estudio de caso, en una empresa con sede en Alemania. El marco de decisión contiene un resumen de los criterios y las variables relevantes para la toma de decisiones en el área de SSM y una descripción de cómo estos criterios y variables interactúan con los posibles resultados. El capítulo 4 proporciona a los responsables un procedimiento paso a paso para guiarlos a través de la implementación de la metodología de evaluación de proveedores sostenibles en las empresas. Se explican las mejores prácticas para la implementación del marco y se propone una ilustración del marco utilizando un estudio de caso detallado.

El capítulo 5 explora las prácticas de la cadena de suministro sostenible en la industria y propone un modelo de decisión de diseño de la cadena de suministro para ayudar a los gerentes a diseñar una estrategia adecuada de la cadena de suministro (SCD) conforme a sus necesidades. El modelo propuesto tiene en cuenta los comentarios relacionados con los problemas de compras a los que se enfrentaron los responsables en el mercado de componentes electrónicos en el año 2018, como la escasez y los largos retrasos en la entrega, causados por la alta demanda de ciertos componentes electrónicos. Se realizó un conjunto de entrevistas con los profesionales afectados para reflejar estos problemas. La planificación
adecuada de los pronósticos teniendo en cuenta las estrategias de fuentes alternativas es clave para prevenir o mitigar los efectos ocasionados por dicha escasez. Así bien, este estudio desarrolla un marco de decisión de SCD, basado en los resultados de la fase de investigación empírica, para ayudar a los responsables a diseñar la estrategia de cadena de suministro más adecuada para un determinado producto o grupo de productos.

El capítulo 6 brinda a los responsables algunas pautas sobre cómo las empresas pueden integrar adecuadamente los aspectos de sostenibilidad en el proceso de selección de proveedores, proporcionando un ejemplo de implementación en una empresa alemana. Se presenta y explica un modelo para el proceso de selección de proveedores externos; a continuación, el capítulo describe un marco y explica cómo se aplica un MCDM, combinado con la metodología TOPSIS, para apoyar a los gerentes en todo el proceso de decisión de selección de proveedores. La aplicación del MCDM se desarrolló basándose en la revisión de la literatura y su eficacia se validó a través de un estudio de caso. Además de esto, el MCDM se aplicó en los capítulos 3 a 6. Debido a que el modelo de decisión propuesto aquí se basa en una aplicación de ANP, se espera que el modelo de decisión tenga una gran aceptación entre los tomadores de decisiones en los campos de SSM y SCM. Esto se debe al hecho que este método MCDM ayuda a identificar la interacción entre los principals criterios, los subcriterios y los escenarios alternativos. Así bien este método se aplica ampliamente y es práctico para utilizarse en combinación con otras metodologías.

En el capítulo 7, se desarrolla un modelo de SSCRM para ayudar a los responsables de la cadena de suministro a evaluar posibles riesgos teniendo en cuenta las características de sostenibilidad. El modelo sigue las pautas descritas por la normativa ISO 31000 en su última revisión y se valida a través de su implementación en una empresa en Alemania. La eficiencia y viabilidad del modelo se analizan a través de talleres y entrevistas con responsables y compradores de la cadena de suministro. Para la evaluación de los eventos de riesgo se utiliza un FMEA, y los criterios de riesgo se definen para simplificar el proceso de evaluación. Se propone una clasificación de categorías de riesgo para priorizar los eventos de riesgo. Sin embargo, se observa que las políticas de riesgo deben definirse de manera que los responsables de la cadena de suministro no subestimen los eventos de riesgo. Los responsables de la cadena de suministro y los gerentes de decisión involucrados en el proceso requieren de la capacitación necesaria para evitar tomar decisiones puramente subjetivas, con vagas percepciones e influenciadas por prejuicios.
Finalmente, el capítulo 8 verifica y valida la efectividad y eficiencia de la metodología Six Sigma para la mejora de procesos en general, y para la reducción de los costes de “mala calidad” (COPQ) en las áreas de SSM y SCM en particular. En el estudio se identifica la necesidad de definir el coste de “mala calidad” (COPQ) en acorde con el caso específico a tratar, demostrando que la estandarización del término no sería válida ni para todas las empresas ni para todos los casos. Este término ha de definirse específicamente adecuándose a cada empresa o caso. El coste de calidad (COQ) incluye los costes totales de conformidad y no conformidad (COPQ). Mientras el coste de “mala calidad” (COPQ) está principalmente afectado por defectos en productos y servicios, el coste de conformidad es entendido como los costes de prevención necesarios para evitar productos o servicios defectuosos. Costes de conformidad, tales como los costes por las auditorías internas y externas, costes de supervisión y costes por la realización de inspecciones sobre los productos recibidos de proveedores (Machowski and Dale, 1998; Murumkar, Teli and Loni, 2018). Se ha identificado la necesidad de subcategorizar el término COPQ en tres categorías: (1) costes relativos por defectos de proveedores (SCOPQ); (2) costes relativos por defectos internos (ICOPQ); y (3) costes relativos por defectos reclamados por clientes (CCOPQ).

1- SCOPQ es definido como los costes asociados con defectos y deficiencias originadas por proveedores externos. Por ejemplo, pueden incluir costes como: incidentes de proveedores externos como el no envío del producto o el retraso en el envío, costes por desabastecimiento, costes derivados de defectos, costes de supervisión, costes por parada de producción, costes de reproceso y rechazo, reclamaciones, costes administrativos, etc.

2- ICOPQ es definido como los costes asociados con defectos y deficiencias identificadas por la empresa antes que el producto o servicio es enviado al cliente. Estos costes ocurren cuando los resultados del trabajo se desvían de la especificación. Por ejemplo, podría tratarse de: costes de reproceso y rechazo, análisis de defectos, rediseño, inspecciones, re-testing, por falta de flexibilidad y adaptabilidad, costes de supervisión, reclamaciones, costes administrativos, costes por parada de producción, otras pérdidas como deficiente gestión de la información, etc.

3- CCOPQ es definido como los costes asociados con defectos y deficiencias encontradas después que el producto o servicio es enviado al cliente, provocando insatisfacción del cliente. Por ejemplo, podría incluir los costes de: sanciones de clientes, reclamaciones, retirada de
productos, supervisión, por retrasos en la entrega, por reparaciones o rehacer los servicios, garantía, pérdidas causadas por reducción de las ventas, medio ambiente, etc.

9.1.2 Contribución teórica

La fase de investigación empírica, descrita en los capítulos 2 a 8, ofrece a los académicos más hallazgos empíricos sobre las áreas de SSM y SCM en general y en el proceso de toma de decisiones en particular. En este sentido, el capítulo 2 actualiza la literatura de fabricación o compra con nuevos hallazgos de investigación. Los resultados de este capítulo sugieren que los profesionales deben combinar la teoría de visión basada en recursos (resource-based view), la teoría de la gestión estratégica (strategic management) y la teoría de economía de costes de transacción (transaction cost economics) para evaluar decisiones sobre la ubicación de fabricación. El coste, la estrategia y las capacidades parecen ser los criterios más significativos, sugiriendo que las empresas generalmente resuelven los problemas tácticos de fabricación o compra buscando lograr ahorros en costes y conseguir ventajas estratégicas u operativas. Los resultados se ajustan al marco propuesto por Brem y Elsner (2018), donde la relevancia de la estrategia de una empresa garantiza la identificación de sus competencias básicas. El capítulo 2 pertenece a un artículo publicado en la revista European Research on Management and Business Economics en el año 2018. Los resultados de este valioso capítulo demuestran la originalidad y la calidad de la investigación, ya que cumple con todos los requisitos de publicación de la revista.

En el capítulo 3 se desarrolla y propone un marco que introduce una relación de causa-efecto entre los criterios relevantes, las variables y la matriz de decisión estandarizada. Adicionalmente, se presenta una aplicación MCDM, que se aplicará junto con la metodología TOPSIS, como una herramienta eficiente para abordar las matrices de decisión. Esta aplicación combinada se desarrolló a través de la revisión de la literatura y se aplica en los capítulos 3 a 6. La necesidad de aplicar metodologías MCDM en el campo de SCM ha sido mencionado por diferentes investigadores (Beck, 2013). Por ello, esta investigación propone una combinación de las metodologías MCDM y TOPSIS para tomar decisiones estratégicas de abastecimiento (capítulo 3), realizar evaluaciones de proveedores (capítulo 4), tomar decisiones de diseño de la cadena de suministro (capítulo 5) y decisiones de selección de proveedores (capítulo 6). El artículo resumido en el capítulo 4 ha sido aceptado por la revista Dirección y Organización (DYO), una revista indexada en la base de datos de Scopus y Thomson Reuters que sólo publica artículos de alta calidad. El artículo en el capítulo 5 ha sido aceptado como parte de un libro publicado para la Universidad de Heilbronn en Alemania por
la editorial Springer Publishing Group, demostrando la aplicabilidad de los resultados del artículo, evaluado y aceptado por expertos de diversas universidades y países.

El modelo de SSCRM introducido en el capítulo 7 representa la primera metodología de evaluación práctica del SSCRM. El modelo contribuye al campo de estudio de la investigación de operaciones al proponer un nuevo enfoque para un problema que no se había abordado hasta ahora. El modelo también contribuye a la investigación en el campo del SCM, ya que integra una amplia gama de criterios y variables para evaluar y priorizar los eventos de riesgo. Sin embargo, el documento extendió el marco de SCD desarrollado por Beck (2013) al integrar la metodología TOPSIS para determinar y evaluar los escenarios más adecuados de SCD y definir la ponderación de los tomadores de decisiones según Boran et al. (2009). Una de las principales contribuciones de esta tesis es el desarrollo de un modelo para apoyar a los profesionales en la toma de decisiones en los campos de SSM y SCM. El problema se modela según la metodología ANP y se muestra en el diagrama de la Figura 9-1.

El capítulo 8 verifica y valida la eficiencia de la metodología Six Sigma mediante un estudio de caso en una empresa alemana. De hecho, este capítulo enfoca el problema de los costes por “mala calidad” relacionado con los proveedores externos específico de una empresa alemana. Investigadores y profesionales desean saber qué metodología es la más adecuada para mejorar un determinado proceso. De hecho, las metodologías KVP (Kaizen), Lean (PDCA) y Six Sigma (DMAIC / DMADV) se pueden aplicar para mejorar procesos. Asimismo, se propone la valoración del grado de dificultad del proceso y el alcance de la interfaz como principales criterios de selección de la metodología. Mientras que la metodología KVP se prefiere para los ámbitos pequeños con un grado bajo de dificultad, la metodología Lean se aplica principalmente para los ámbitos como parte de un proceso con pocas interfaces y un grado medio de dificultad. Finalmente, Six Sigma es la metodología más adecuada para ámbitos con un alto grado de dificultad o problemas que involucran procesos multifuncionales, involucrando varias interfaces. Por lo tanto, la metodología Six Sigma aplicada se adaptó al problema inicial. Este capítulo adelanta un marco para reducir el COPQ causados por proveedores externos, mejorando y estandarizando el proceso de reclamaciones de proveedores externos en una empresa. El estudio valida y verifica la eficiencia de la metodología DMAIC como marco, demostrando ser de ayuda para identificar varias iniciativas para optimizar la reducción de costes de calidad.
Los investigadores pueden desarrollar el marco propuesto integrando criterios adicionales para evaluar y priorizar escenarios y reducir el COPQ relacionado con los proveedores y mejorar la eficiencia del enfoque.
Figura 9.1. Jerarquía de selección de problemas de abastecimiento estratégico (Red de decisiones)
En el modelo propuesto en esta tesis, el objetivo, los grupos principales y los subcriterios se definen de acuerdo con el problema tratado. Los posibles escenarios y las posibles opciones de aprovisionamiento se identifican para crear una red de decisión. La ponderación normalizada de cada criterio se obtiene al realizar una comparación por pares de los criterios principales y subcriterios con respecto a los objetivos. Para mejorar la operacionalización, se definen seis criterios principales, que limitan los subcriterios a los TOP5 más relevantes. Para crear las matrices, se hacen comparaciones pareadas basadas en valores numéricos difusos definidos en una escala de 0 a 2. Las evaluaciones se realizan entre criterios comparados por pares. Dentro de estas evaluaciones; "1" se usa cuando los criterios tienen la misma importancia, 0 cuando un criterio tiene menos importancia que el otro y 2 cuando un criterio tiene mayor importancia que el otro.

La evaluación de los subcriterios se resume en el respectivo criterio principal. Luego, utilizando un enfoque de TOPSIS difuso, se clasifican las alternativas según las ponderaciones calculadas de los criterios principales y la calificación evaluada por los responsables de la toma de decisiones definidos previamente. Los valores de configuración fijados ayudan a tratar la incertidumbre en la evaluación de alternativas en esta fase. Las alternativas se evalúan en una escala de 1 a 5, donde una puntuación de 1 significa que la condición no cumple con los requisitos, una puntuación de 2 que los requisitos se cumplen sólo en parte, una puntuación de 3 que los requisitos se cumplen casi por completo, una puntuación de 4 que cumple con todos los requisitos y una puntuación de 5 que la condición alcanza un nivel de excelencia. Este modelo apunta a mejorar las soluciones anteriores al problema de seleccionar la mejor opción o escenario de abastecimiento estratégico de un conjunto de alternativas potenciales basadas en los criterios principales. En este modelo se emplean matrices de comparación por pares para determinar las ponderaciones y, específicamente, para investigar el impacto de los criterios de riesgo en cada alternativa.

Los resultados se ven afectados por la ponderación asignada a cada persona que toma las decisiones, que no es difusa ni variable, sino que es fija: DM1 se fija en 0.406; DM2 se fija en 0.238; y DM3 se fija en 0.356, de modo que el total de la ponderación es 1. La solución final se obtiene a través de una serie de pasos basados en el método TOPSIS, donde la mejor alternativa es la que está más cerca de la solución ideal positiva. El objetivo es clasificar las alternativas según su mejor ajuste para que la opción de escenario o fuente con la puntuación y rango más alto se pueda elegir al final. Es cierto que los escenarios con la puntuación más
alta también tienen el menor riesgo de suministro. Se eligió un criterio de "inducción" de comparación como un criterio de control según la relación entre los criterios principales, incluyendo los subcriterios y los posibles resultados (por ejemplo, alternativas de aprovisionamiento), según lo propuesto por Gencer y Gürpınar (2007). Saaty (1999) definió este tipo de comparación: el criterio de control de "inducción", utilizado en las redes, y ayuda a identificar la interacción entre los criterios principales (y los subcriterios) y las posibles alternativas aceptadas durante la fase de toma de decisiones.

### 9.2 Limitaciones y futuras líneas de investigación

#### 9.2.1 Limitaciones de la tesis

En primer lugar, la revisión de la literatura en el capítulo 2 proporciona un análisis en profundidad centrado exclusivamente en los artículos publicados por siete revistas de prestigio indexadas en el informe de JCR. En segundo lugar, sólo se consultaron las bases de datos ProQuest, Scopus y Web of Science en el presente estudio, implicando la posibilidad que no se cubran todos los artículos en el campo de fabricación o compra, dejando de lado otras fuentes como libros o informes de conferencias. Esta limitación con respecto a la selección de las fuentes analizadas difícilmente se puede evitar en cualquier revisión de la literatura.

En la fase de investigación empírica en el capítulo 3, sólo se analiza un estudio de caso en una empresa con un conjunto de 24 decisiones de fabricación o compra, tomadas en el momento del estudio o antes del estudio, sin compararlo con otros estudios de caso; sería recomendable comparar esta investigación con otros estudios de caso, sucursales y regiones. La investigación en el capítulo 4 se centra exclusivamente en dos estudios de caso ubicados en China y Eslovaquia, de nuevo sin compararlo con otros estudios. Además, ningún estudio anterior había evaluado la integración de la metodología TBL (Triple Bottom Line) en un marco, implicando que se requieran más evaluaciones. Una posible limitación de este estudio en el capítulo 5 se deriva del hecho que el análisis presentado, solamente analiza un estudio de caso; la investigación se centra en la fase de compras entre las empresas y sus proveedores y el diseño de la estrategia de SCD más adecuado para satisfacer las necesidades respectivas de los clientes. Las fases de los procesos internos de la empresa, la distribución y la entrega al cliente como parte de la estrategia de SCD no se incluyen en este estudio. El modelo de decisión de diseño de la cadena de suministro propuesto se basa en la metodología ANP.
(proceso de red analítica) desarrollado por Saaty (1996) y sus implementaciones posteriores por Gencer y Gürpinar (2007). El modelo se divide en 9 pasos: (1) analizar el grupo de clientes; (2) analizar el grupo de productos; (3) análisis de proveedores externos; (4) determinar el objetivo y los criterios del diseño de la cadena de suministro (SCD) a partir del marco; (5) determinar fuentes alternativas (alternativas de los proveedores externos seleccionados; (6) definir la ponderación de los tomadores de decisiones; (7) construir diferentes escenarios de SCD; (8) confeccionar las matrices de comparación pareadas (PCM); y (9) tomar la decisión basándose en la evaluación de la SCD preferida utilizando la metodología TOPSIS. Los resultados pueden diferir de los obtenidos si se aplica otro MCDM. De hecho, una limitación potencial es el uso de la metodología de pares para ponderar los principales criterios y subcriterios.

Sin embargo, la metodología de pares (PCM) es ampliamente utilizada e implementada tanto por investigadores como por profesionales (especialmente cuando las filas y columnas tienen los mismos parámetros). Una posible limitación de los capítulos 6, 7 y 8 es el hecho que la investigación sólo se centra en un estudio de caso en una empresa en Alemania, sin tener en cuenta estudios de casos adicionales. La integración del marco y el proceso de ISO 31000 en la empresa en el capítulo 7 demostró que el proceso de SSCRMM en la empresa es eficiente, pero ¿tiene aceptancia la normativa ISO 31000 en otras sucursales, regiones y empresas? ¿encuentran las empresas la adopción de la normativa ISO 31000 comprensible y útil en diferentes contextos? Los profesionales involucrados en los estudios de caso (capítulos 3 a 8) son seleccionados en base a su experiencia en el manejo de toma de decisiones en los campos de SCM, SSM y transacciones de externalización. La mayoría de ellos son responsables de la cadena de suministro. En la fase de investigación empírica, las entrevistas estandarizadas se realizan utilizando una metodología general basada en cuestionarios prediseñados. De esta manera, se evitan posibles prejuicios y es posible hacer una comparación cualitativa; aún así, los resultados podrían estar influenciados por cierta parcialidad.

Además, el estudio de caso considerado se refiere a un fabricante de soluciones electrónicas e industriales que opera en un mercado específico y tiene una ubicación descendente de su cadena de suministro (downstream SC). Por lo tanto, las empresas que están ubicadas en posiciones descendentes de su SC, como los fabricantes de productos químicos, deben tener en cuenta otros criterios adicionales durante la toma de decisiones en las áreas de SSM y SCM. Las actividades de SC descendentes (downstream) comprenden la etapa de procesamiento de las materias primas, que también puede involucrar la venta de bienes al
consumidor final, mientras que las actividades ascendentes (upstream) abarcan la red de suministro de proveedores de la empresa y sus propios proveedores.

En resumen, una de las principales limitaciones de esta tesis es que la metodología del estudio de caso es fundamentalmente cualitativa, más que cuantitativa. No se realizaron encuestas entre empresas (clientes o proveedores externos) como parte de esta investigación para analizar sus procesos de fabricación o compra; en cambio, estos procesos se discutieron principalmente a través de estudios de casos y, por lo tanto, los resultados obtenidos son menos generalizables. Sin embargo, esta limitación se compensa con la gran cantidad de datos, información y detalles recopilados a través de los diferentes casos analizados, que es mucho más difícil de lograr con los resultados más generales de una encuesta. La experiencia de primera mano del autor de la tesis como empleado en una empresa en la que participa en la toma de decisiones en los campos de SCM y SSM le ha aportado una ventaja competitiva y fue otra razón por la que se prefirió una metodología de estudio de caso en lugar de una encuesta. Esta tesis se debió en parte al deseo del autor de resolver problemas directamente aplicables a su empresa y ofrecer algunas pautas a otros profesionales a cargo de los procesos de fabricación o compra y mejora de procesos. Para garantizar la confiabilidad de tales pautas, se decidió revisar estudios previos realizados por otros académicos en los campos mencionados y desarrollar una tesis doctoral.

9.2.2 Posibilidades para futuras líneas de investigación

Claramente todavía hay mucho espacio para el crecimiento y mejora en la literatura sobre las áreas de SSM, SCM y Six Sigma. Por ejemplo, la literatura académica tiene varios estudios que se centran sólo en un enlace que aborda las decisiones de fabricación o compra (empresa focal a directores o empresa focal a agentes). Una oportunidad para futuros investigadores también se deriva de la validación empírica del marco teórico propuesto. Básicamente, ¿requiere el proceso de fabricación o compra un especialista en este campo dentro de las empresas? ¿existe tal puesto de trabajo? ¿Existe algún programa de formación? ¿cómo se transfiere este conocimiento a la próxima generación? Los aspectos tales como la proximidad a los mercados, la situación macroeconómica y política, las implicaciones comerciales, la rentabilidad, la diferenciación técnica, la capacidad de los fabricantes contratados, y la valoración de actividades principales o secundarias influyen fuertemente en esta decisión. Es cierto que los temas de investigación enumerados aquí ya han sido investigados; sin embargo, existe la necesidad de continuar actualizando la decisión dicotómica de fabricación o compra para proporcionar a la comunidad científica nuevos conocimientos de investigación. ¿Qué
consideraciones se tienen en cuenta durante el proceso de decisión de fabricación y compra?
¿Hasta qué punto las decisiones de fabricación y compra tienen un impacto en el rendimiento operativo de las empresas? ¿Por qué se ignoran los costes fijos y ocultos en las decisiones de fabricación y compra? ¿Cómo pueden las empresas implementar estos modelos estructurados de toma de decisiones? En lo que respecta al proceso de decisión de fabricación y compra, los modelos teóricos o explicaciones mencionados en el pasado no son suficientes para comprender el proceso de subcontratación. Se ha de aprender de lecciones pasadas de manera que la próxima vez se puedan obtener resultados diferentes.

El análisis empírico en esta investigación se realiza desde el punto de vista de un comprador que se encuentra en la categoría de "Empresa", tal como se define en el capítulo 2. El potencial de futuras investigaciones puede estar en la investigación de estos aspectos desde diferentes ángulos; por ejemplo, con un enfoque en las perspectivas de cadena, red o diádico. Por otro lado, ¿es la internalización el fin de la clásica tendencia a la subcontratación y externalización?

En los capítulos 3 a 8, sería aconsejable comparar los resultados de los estudios de caso analizados con los de otros estudios de caso relacionados con empresas de otras sucursales y regiones. La validación empírica de otros estudios de caso dentro del marco teórico propuesto sería otra oportunidad para futuras investigaciones.

La literatura sobre decisiones de evaluación de proveedores sostenibles, que se detalla en el capítulo 4, también debe actualizarse. ¿Qué factores se consideran durante el proceso de decisión de compra sostenible? ¿Cuál es el impacto de la evaluación de proveedores externos en el rendimiento operacional de las empresas? Se deben hacer estas y otras preguntas similares para mejorar las prácticas de evaluación de proveedores desde un punto de vista sostenible. Los investigadores pueden desarrollar el marco propuesto al integrar criterios adicionales para evaluar y priorizar los escenarios con la metodología TOPSIS mejorando la efectividad del enfoque introducido en el capítulo 5. Esta investigación presenta un caso de estudio en la industria electrónica; también se pueden considerar estudios de caso de otros sectores. Algunas preguntas de investigación específicas que pueden explorarse en el futuro incluyen, entre otras, las siguientes: ¿Cuáles son los desafíos planteados por las estrategias lean, leagile, agile y CSR? ¿Ayudan las estrategias lean y de sostenibilidad a las empresas a ser más eficientes? ¿Se requiere una nueva terminología después de la inclusión de los criterios de CSR para mejorar la calidad en el proceso de toma de decisiones de diseño de la
cadena de suministro? ¿Qué capacidades son necesarias para operar con éxito en una cadena de suministro diferenciada?

En el capítulo 6, se consideran los aspectos interorganizacionales del área de SCM y SSM, como la integración de factores relacionados con la sostenibilidad en el proceso de selección de proveedores, ya que el proceso de selección de proveedores propuesto se implementa en diferentes plantas dentro del grupo de la empresa del estudio de caso. Sin embargo, una mayor investigación en otras industrias y regiones puede ofrecer oportunidades para futuras investigaciones. Se necesita una investigación más cualitativa para profundizar en los diversos riesgos de la cadena de suministro sostenible que requieren evaluaciones y estrategias de riesgo distintas (prevención, transferencia, aceptación, explotación, intercambio, mejora, mitigación, etc.). A pesar que el proceso de SSCRM propuesto en el capítulo 7 arroja luz sobre el efecto de las actividades de gestión de riesgos de la cadena de suministro ascendente en la mejora de la valoración del riesgo, sería interesante investigar qué otros factores y criterios contribuyen a la valoración del riesgo de la cadena de suministro sostenible ascendente.

En el capítulo 8 se implementa un marco siguiendo la metodología Six Sigma (DMAIC) para reducir el COPQ relacionado con los proveedores externos en una empresa alemana. El proyecto valida la eficacia y la eficiencia de la metodología Six Sigma mejorando y estandarizando el proceso de reclamaciones de proveedores externos. Sin embargo, una mayor investigación aplicando esta metodología en otras empresas o en multiples estudios de caso ofrecería oportunidades para futuras investigaciones.

### 9.3 Bibliografía


9. Conclusions and implications

In conclusion, this research conceptualizes SSM and SCM decision support as firms’ proficiency in leveraging internal and external decisions to support their procurement processes efficiently, and it examines the roles of decision makers and how they influence on firms’ performance. Based on an in-firm case study on an electronics firm in Germany, this study presents mechanisms and pathways through which procurement and strategic sourcing decisions can be made in a structured and efficient manner: (1) a developed model with its corresponding frameworks, enabling decision makers, practitioners and researchers to develop dynamic capabilities; and (2) practitioners enabled dynamic capabilities provide the knowledge to make SSM and SCM decisions in an effective and efficient manner so that successful transactions create additional business value for firms – more business value, in fact, than one would expect. The formation of SSM and SCM-enabled dynamic capabilities is found to be an important driver for competitive performance. Likewise, the effectiveness and efficiency of the Six Sigma methodology for the improvement of processes in the areas of SSM and SCM have been demonstrated with the results obtained in Chapter 8.

9.1 Contributions of this thesis

The contributions of this thesis, presented in managerial, theoretical and academic terms, are structured according to the three main research phases of the thesis: the literature review, the empirical research and the design of SSM, SCM and Six Sigma decision models, also making reference to the thesis chapters (2-8).

9.1.1 Managerial contribution

Despite the high number of tools to make SSM and SCM decisions in firms, the empirical studies explaining the implementation of sustainability criteria and risk assessment guidelines, according to the ISO 26000 and ISO 31000 standards respectively, are scarce. Whereas SSM decisions refer mainly to the insourcing and outsourcing options, SCM decisions are only related to the decisions concerning procurement processes. However, in spite of the relevance and potential of SSM and SCM for business activities, the empirical work needs to be continuously updated in order to respond to the rapid changes in terms of environmental factors, like normative and political constellations, the market situation, etc. Due to this
continuously changing environment, firms need to reinforce their ability to adapt their processes to those changes by evaluating the relevant role strategic SSM plays in the firms’ performance. This research results are influenced by those changes because of the current allocation problems, which cause important delays in the delivery of electronic components worldwide. The present doctoral research tries to respond to this shortage by developing a set of frameworks to support decision makers and managers in the assessment of SSM and SCM decisions.

Additionally, this thesis seeks to verify the effectiveness and efficiency of the Six Sigma methodology to improve processes in the business world. After reviewing the make-or-buy literature in Chapter 2, the main findings from the literature are outlined; specifically, key attributes for improving the relationship with external providers are listed. In Chapter 3 a framework is developed to help managers assess make-or-buy decisions. This framework is verified and validated in a case study of a firm based in Germany. The SSM-decision framework contains a summary of relevant criteria and variables for decisions on SSM and a description of how these criteria and variables interact with the possible outcomes.

Chapter 4 provides managers with a step-by-step procedure to guide them through the implementation of the sustainable supplier evaluation methodology in firms. Best practices for the implementation of the framework are explained and an illustration of the framework provided using a detailed case study.

Chapter 5 explores sustainable supply chain practices in the industry and proposes a supply chain design decision model to help managers craft an appropriate supply chain design (SCD) strategy according to their needs. The proposed model takes account of inputs regarding the procurement problems faced by managers in the electronic market in 2018, such as shortages and long delivery delays, caused by the high demand of certain electronic components. A set of interviews with affected practitioners was performed to reflect these issues. Appropriate forecast planning considering second source strategies is key preventing or mitigating the effects of shortages. Based on the results of the empirical research phase, an SCD decision framework is now available to help managers design the appropriate supply chain strategy for a certain product or product group.

Chapter 6 gives managers some guideline on how firms can properly integrate sustainability aspects in the supplier selection process, providing an example of implementation in a German firm. A model for the external supplier selection process is presented and explained; next, the chapter describes a framework and discusses how an MCDM is applied, combined with the TOPSIS methodology, for supporting managers throughout the supplier selection
decision process. The MCDM application was developed drawing on the literature review and its efficiency was validated through the case study. In addition to this, the MCDM was applied in Chapters 3 to 6. As the decision model proposed here is based on an ANP application, it is expected that the decision model finds a high acceptance under decision makers for SSM and SCM decisions. This is due to the fact that this MCDM method helps with identifying interaction between main clusters, sub-criteria and alternative scenarios and is widely applied as well as practical to conduct in contrast to other MCDM methodologies.

Chapter 7 develops an SSCRM model to assist supply chain managers in evaluating sustainable supply chain risks. The model follows the guidelines of the updated ISO 31000 standard and is validated through its implementation in a firm in Germany. The model’s efficiency and viability are analyzed via workshops and interviews with supply chain managers and purchasers.

An FMEA is used to evaluate of risk events, and risk criteria are defined in order to simplify the assessment process. A classification of risk categories is proposed to prioritize risk events. Nevertheless, it is noted that risk policies must be defined so that risk events are not underestimated by certain supply chain managers. The supply chain managers and decision managers involved in the process require training, as this allows them to make decisions based on factors other than purely subjective preferences, vague judgments and perceptions, and avoiding bias.

Finally, Chapter 8 verifies and validates the effectiveness and efficiency of the Six Sigma methodology for the improvement of processes in general, and for the reduction of "poor quality" (COPQ) costs in the areas of SSM and SCM in particular. This study identifies the need to define the cost of "poor quality" (COPQ) in accordance with the specific case to be treated, demonstrating that the standardization of the term would not be valid for all firms or for all cases. This term must be defined specifically adapting to each firm or case.

COQ summarizes the total of conformance and non-conformance COPQ costs. Whereas COPQ is mainly affected by service and product failures, cost of conformance is understood as the preventive costs needed to avoid poor quality. Costs of conformance, such as first and second party audits costs, monitoring costs and incoming quality inspection costs (Machowski and Dale, 1998; Murumkar, Teli and Loni, 2018). It’s identified the need to subcategorize the term COPQ in three categories: (1) supplier related failure costs (SCOPQ); (2) internal related failure costs (ICOPQ); and (3) customer related failure costs (CCOPQ).
1- SCOPQ is defined as the costs associated with defects and deficiencies originated by suppliers. For instance, they could include the costs for: supplier-related incidents like non-delivery and logistic delays, shortages or failure-related costs, monitoring costs, production stop costs, rework costs, complaints, administrative costs, etc.

2- ICOPQ is defined as the costs associated with defects and deficiencies discovered by the firm before the product or service is delivered to the customer. These costs occur when the results of work deviate from the defined specification. For instance, they could include: rework costs, failure analysis, re-designing, re-testing, lack of flexibility and adaptability, production stop costs, scrap, monitoring costs, complaints, administrative costs, and other wastes as poor management of information, etc.

3- CCOPQ is defined as the costs associated with defects and deficiencies found after the customer receives the product or service, leading to customer dissatisfaction. For example, they could include the costs for: customers’ sanctions, complaints, recall costs, monitoring costs, late delivery, repairing goods and redoing services, warranties, losses due to sales reductions, environmental costs, etc.

9.1.2 Theoretical contribution

The empirical research phase, described in Chapters 2 to 8, offers academics further empirical findings on SSM and SCM in general and in the decision-making process in particular. In this sense, Chapter 2 updates the make-or-buy literature with new research findings. The results of this chapter suggest that practitioners should combine the resource-based view, the strategic management theory and the transaction cost economics theory in order to assess manufacturing location decisions. Cost, strategy and capabilities appear to be the most significant criteria, which suggest that firms usually resolve tactical make-or-buy issues seeking to achieve cost savings and strategic or operational advantages. The results are in keeping with the framework proposed by Brem and Elsner (2018), where the relevance of a firm’s strategy ensures the identification of its core competencies. Chapter 2 belongs to an article published in the European Research on Management and Business Economics journal in 2018. The findings of this valuable chapter prove the originality and quality of the research, as it meets all the publication requirements of the journal.

A developed framework is proposed in Chapter 3, which introduces a cause-effect relationship between the relevant criteria as well as variables and the standardized
decision matrix. Additionally, an MCDM application, to be applied in conjunction with the TOPSIS methodology, is introduced as an efficient tool for addressing decision matrices. This combined application was developed by means of the literature review and is applied in Chapters 3 to 6. The need to apply MCDM methodologies in SCM has been mentioned by different researchers (Beck’s dissertation, 2013). Hence, this research proposes a combination of the MCDM and TOPSIS methodologies for making strategic sourcing decisions (Chapter 3), conducting supplier evaluations (Chapter 4) and taking supply chain design decisions (Chapter 5) and supplier selection decisions (Chapter 6). The article summarized in Chapter 4 has been accepted by Dirección y Organización (DYO), a journal indexed in Scopus and Thomson Reuters data base that only publish high quality articles. The article Chapter 5 has been accepted as part of a book released by the Heilbronn University in Germany and published by the Springer Publishing Group, as the applicability of the article’s findings has been proven by experts from various universities and countries.

The SSCRM model introduced in Chapter 7 represents the first SSCRM practical assessment methodology for evaluation in SSCRM. The model contributes to the field of study of operations research by proposing a new approach to a problem that had not been addressed so far. The model also contributes to SCM research, since it integrates a comprehensive range of criteria and variables to evaluate and prioritize risk events. Nevertheless, the paper extended the SCD framework developed by Beck (2013) by integrating the TOPSIS methodology to assess and evaluate the best SCD scenarios and defining the weighting of decision makers according to Boran et al. (2009). One of the main contributions of this thesis is the development of a model to support practitioners in making SSM and SCM decisions. The problem is modeled based on the ANP methodology and shown in the diagram in Figure 9-1.

Chapter 8 verifies and validates the efficiency of the Six Sigma methodology through a case study in a German firm. In fact, this chapter focuses on the problem of "poor quality" costs related to external suppliers specific to a German firm. Practitioners and researchers want to know which methodology best fit for a certain process improvement. In fact, KVP (Kaizen), Lean (PDCA) and Six Sigma (DMAIC/DMADV) methodologies can be applied for the improvement of processes. Likewise, it is proposed to assess the degree of difficulty of the process and the scope of the interface as the main criteria for selecting the methodology. One of the main selection criteria relies on the degree of difficulty of the process and the scope of the interface. Whereas KVP is preferred for small scopes with a low grade of difficulty, Lean is applied primarily for scopes as part of processes with few interfaces and
medium grade of difficulty. Finally, Six Sigma is the most suitable methodology for scopes with a high grade of difficulty or problems involving cross-functional processes. Therefore, the applied Six Sigma methodology suited with the initial problem statement.

This chapter advances a framework for reducing supplier-related COPQ by improving and standardizing the supplier complaint process in a firm. The project validates the effectiveness and efficiency of the DMAIC methodology as a framework that has been demonstrated to help organizations identify various initiatives for optimal reduction of quality costs. Researchers can develop the proposed framework by integrating additional criteria for evaluating and prioritizing scenarios to reduce supplier-related COPQ and enhance the efficiency of the approach.
Figure 9.1: Strategic Sourcing Selection Problem Hierarchy (Decision Network)
In the model proposed in this thesis, a goal, main clusters and sub-criteria are defined according to the problem addressed. Possible scenarios and sourcing options are identified to create a decision network. The normalized weight of each cluster is obtained by performing a pairwise comparison of the main clusters and sub-criteria with respect to the goal. In order to improve the operationalization, six main clusters are defined, limiting the sub-criteria to the most relevant TOP5. To create the matrices, paired comparisons are made based on defined fuzzy numeric values on a scale of 0 to 2. Evaluations are carried out between pairwise compared criteria. Within these evaluations; "1" is used when the criteria have equal importance, 0 that one criterion has less importance than the other, and 2 that one criterion has more importance than the other.

The evaluation of the sub-criteria is summarized in the respective main cluster. Then, using a fuzzy TOPSIS approach, alternatives are ranked based on the calculated weights of the main clusters and the scoring assessed by the defined decision makers. Fuzzy set values in this phase help in dealing with the uncertainty in the evaluation of alternatives. Alternatives are assessed on a scale of 1 to 5, where a score of 1 means that the condition does not meet the requirements, a score of 2 that the requirements are only partly met, a score of 3 that the requirements are almost completely fulfilled, a score of 4 that the requirements are fully met and a score of 5 that the condition reaches a level of excellence. This model aims to enhance previous solutions to the problem of selecting the best strategic sourcing option or scenario from a set of potential alternatives based on the main clusters. Pairwise comparison matrices are employed in this model to determine weightings and, specifically, to investigate the impact of risk criteria on each alternative.

The results are affected by the weighting allocated to each decision maker, which is not fuzzy, but fixed: DM1 is 0.406; DM2 is 0.238; and DM3 is 0.356, so that the total of the weighting is 1. The final solution is obtained through a series of steps based on the TOPSIS method where the best alternative is the one that is nearest to the positive ideal solution. The goal is to rank the alternatives based on their best fit so that the scenario or sourcing option with the highest score can be chosen at the end. Admittedly, the scenarios with the highest score also have the lowest supply risk. A comparison-“inducing” criterion was chosen as a control criterion according to the relationship between the main clusters, including sub-criteria and possible outputs (e.g. sourcing alternatives), as proposed by Gencer and Gürpınar (2007). This type of comparison-“inducing” control criterion, used in networks, was defined by Saaty.
(1999) and helps with identifying the interaction between the main criteria (and sub-criteria) and possible alternatives accepted during the decision-making phase.

### 9.2 Limitations of this thesis and future research

#### 9.2.1 Limitations of this thesis

Firstly, the literature review in Chapter 2 provides an in-depth analysis focused exclusively on articles published in seven prestigious journals indexed on the JCR report. Secondly, only the ProQuest, Scopus and Web of Science databases were queried in the present study, which means that it may not cover all the articles in the make-or-buy field, leaving aside other sources such as books or conference reports. This limitation concerning the selection of sources analyzed can hardly be avoided in any literature review.

In the empirical research phase in Chapter 3 only an in-firm case study with a set of 24 make-or-buy decisions, taken at the time of the study or before the study, is analyzed, without comparing it with other case studies; it would be advisable to compare this research with other case studies, branches and regions. The in-depth investigation in Chapter 4 is focused exclusively on two case studies located in China and Slovakia, again without comparing it with other studies. Furthermore, no previous studies had evaluated the integration of the TBL (Triple Bottom Line) methodology into a framework, which means more evaluations would be required. A potential limitation of this study in Chapter 5 stems from the fact that the in-depth analysis presented discusses only one case study; the research focuses on the procurement phase between firms and their suppliers and the design of the most suitable SCD strategy to meet the respective customer needs. The phases of firms’ internal processes, distribution and customer delivery as part of the SCD strategy are not included in this study.

The proposed supply chain design decision model is based on the ANP (analytic network process) methodology developed by Saaty (1996) and its subsequent implementations by Gencer and Gürpinar (2007). The model is split into 9 steps: (1) analyzing the customer group; (2) analyzing the product group; (3) analyzing external providers; (4) determining the goal and SCD criteria from the framework; (5) determining second sources (alternatives of the selected external providers; (6) defining the weight of decision makers; (7) building different SCD scenarios; (8) making the paired comparison matrices (PCM); and (9) deciding based on the evaluation of the preferred SCD using the TOPSIS methodology. Results may differ from
those obtained if another MCDM is applied. In fact, one potential limitation is the use of the pairwise methodology to weight the main clusters and sub-criteria. However, PCMs are widely used and implemented by both researchers and practitioners (especially where rows and columns have the same parameters). A possible limitation of Chapters 6 and 7 is the fact that the research is only focused on an in-firm case study in Germany, without taking into account additional case studies. The integration of the ISO 31000 framework and process into the firm in Chapter 7 showed that the firm’s SSCR process is efficient, but is ISO 31000 accepted in other branches, regions and firms? Do firms find the adoption of ISO 31000 understandable and useful in different contexts?

Practitioners involved in the case studies (Chapter 3 to 8) are selected based on their experience in dealing with SCM and SSM decisions and outsourcing transactions; most of them are supply chain managers. In the empirical research phase, standardized interviews are conducted using a general methodology based on pre-designed questionnaires. In this way, bias is avoided and it is possible to make a qualitative comparison; even so, the results might be biased. Furthermore, the in-firm case study considered refers to a manufacturer of electronic and industrial solutions that operates in a specific market and is located downstream of its SC. Hence, firms which are located upstream of their SC, like chemical manufacturers, should take into account other or additional criteria for making SSM and SCM decisions. Downstream SC activities comprise the processing stage of raw materials, which can also involve the sale of goods to the final consumer, whereas upstream activities encompass the supply network of firm suppliers and their own suppliers.

In summary, one of the main limitations of this thesis is that the case study methodology is fundamentally qualitative, rather than quantitative. No survey was conducted among firms (clients or external providers) as part of this research to analyze their make-or-buy processes; instead, these processes were discussed mainly through case studies and, therefore, the results obtained are less generalizable. However, this limitation is offset by the wealth of data, information and details collected through the different cases analyzed, which is much more difficult to achieve with the more general results of a survey. The thesis author’s first-hand experience as an employee at a firm where sourcing decisions are made gave him a competitive advantage and was another reason why a case study methodology was preferred over a survey. This thesis was partly driven by his desire to solve problems directly applicable to his firm and offer some guidelines to other professionals in charge of make-or-buy
processes. To ensure the reliability of such guidelines, it was decided to review previous studies by other scholars in the field and undertake a doctoral thesis.

9.2.2 Possibilities for future research

There is clearly still plenty of room for growth and improvement in the SSM and SCM literature. For instance, the academic literature has multiple studies focusing only on one link addressing make-or-buy decisions (focal firm to principals or focal firm to agents). An opportunity for future researchers also stems from the empirical validation of the proposed theoretical framework. Basically, does the make-or-buy process require a make-or-buy specialist within firms? Does such a position exist? Is there a training program in place? How is this knowledge transferred to the next generation? Aspects such as proximity to markets, macroeconomic and political situation, trade implications, profitability, technical differentiation, contract manufacturers’ capability or core or non-core activities strongly influence this decision. Admittedly, the research topics listed here have already been investigated; nevertheless, a need exists to continue updating the dichotomous make-or-buy decision so as to provide the scientific community with new research insights. What considerations are borne in mind during the make-and-buy decision process? To what extent do make-and-buy decisions impact on firms’ operational performance? Why are fixed and hidden costs ignored in make-and-buy decisions? How can organizations implement these structured decision-making models? As far as the make-and-buy decision process is concerned, the aforementioned theoretical models or explanations do not suffice to understand the outsourcing process; things must be done differently next time in order to obtain different outcomes.

The empirical analysis in this research is conducted from the point of view of a purchaser falling under the ‘Firm’ category as defined in Chapter 2. A potential for future research may be further investigating these aspects from different angles; for instance, with a focus on Chain, Network and Dyadic perspectives. On the other hand, is the insourcing the end of the classic outsourcing deal?

In Chapters 3 to 8, it would be advisable to compare the results of the case studies analyzed with those of other case studies relating to firms from other branches and regions. Empirically validating other case studies within the proposed theoretical framework would be another opportunity for future researches. The literature on sustainable supplier evaluation decisions, detailed in Chapter 4, should be updated as well. What factors are considered during the sustainable procurement decision process? What is the impact of supplier evaluation on firms’

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operational performance? These and other similar questions should be asked for improving supplier evaluation practices from a sustainable viewpoint.

Researchers can develop the proposed framework by integrating additional criteria for evaluating and the prioritizing scenarios with the TOPSIS methodology to enhance the effectiveness of the approach introduced in Chapter 5. This research presents a case study from the electronic industry; case studies from other sectors can also be considered. Some specific research questions that can be explored in the future include: what are the challenges posed by lean, leagile, agile and CSR strategies? Do lean and sustainability strategies assist firms in being more efficient? Does the inclusion of CSR criteria in the supply chain design decision-making process call for a new theoretical foundation for quality improvement? Which capabilities are necessary to successfully operate a differentiated SC?

In Chapter 6, inter-organizational aspects of SCM and SSM, like the integration of sustainability-related factors in the supplier selection process, are considered as the proposed supplier selection process is implemented in different plants within the firm’s group. However, further investigation in other industries and regions may offer potential for future research. More qualitative research is needed to go deeper into the various sustainable supply chain risks that require distinct assessment and risk strategies (avoidance, transference, acceptance, exploitation, sharing, enhancement, mitigation, etc.). Even though the SSCRM process proposed in Chapter 7 sheds light on the effect of upstream supply chain risk management activities on risk performance improvement, it would be interesting to investigate what other factors and criteria contribute to upstream sustainable supply chain risk performance. In Chapter 8, a framework is implemented following the Six Sigma methodology (DMAIC) to reduce the COPQ related to external suppliers in a German firm. The project validates the effectiveness and efficiency of the Six Sigma methodology by improving and standardizing the supplier complaint process. However, further research applying this methodology in other firms or in multiple case studies offers opportunities for future research.

9.3 References


10. Appendix

10.1 Accomplishments (Acknowledgments)

10.1.1 Paper 1 (Chapter 2)-Publication


Should we make or buy? An update and review
Rubén Medina Serrano, María Reyes González Ramírez*, José Luis Gasco Gascó
Department of Business Organization, University of Alicante, San Vicente del Raspeig, Alicante, Spain

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ABSTRACT

Whether firms should perform manufacturing activities on their own or buy them from an external provider is a strategic question that many managers from all firm areas have historically asked themselves. The present paper seeks to address this question by developing a theoretical framework which can help managers evaluate sourcing decisions. After discussing a make-or-buy literature review on 7 prestigious academic journals, the most relevant determinants and theories supported from the literature are identified and illustrated within this framework. The results are subsequently outlined, our research work concludes with a reflection on the extent to which this paper can improve the academic understanding of make-or-buy approaches. Our results suggest that practitioners should combine the resource-based view, strategic management and transaction cost economics theories in order to assess manufacturing location decisions.

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1. Introduction

Even though the dilemma faced by managers when it comes to choosing insourcing or outsourcing specific products or services was studied by many researchers in the past, they failed to consider hybrid and plural sourcings. Whereas hybrid sourcing refers to the procurement of the entire volume from a single mode that exhibits mixed governance, plural sourcing results from the simultaneous use of insourcing and outsourcing (Jacobsides & Hitt, 2005; Park & Ro, 2011; Parmigiani, 2007; Puranam, Gulat, & Bhattacharya, 2013). Not only the historical and dichotomous make-or-buy perspective should be taken into account by decision makers, but also hybrid and plural sourcings views as well as the creation of strategic alliances. Furthermore, a distinction needs to be drawn within make-or-buy decisions manufacturing activities and those associated with research and development (R&D) (Brem & Elsner, 2018).

According to Doz, Prahalad, and Hamel (1990), joint ventures provide low-cost, fast access to new markets by sharing risks and borrowing expertise from local partners. Managers and decision makers want to know both which factors are likely to influence a firm’s decision to buy a specific part or service rather than to produce it internally and how the relevant factors should be evaluated in order to ensure that the right decision will be made, thus avoiding future problems and extra costs. A number of researchers have argued that quite a few make-or-buy decisions have an instinctive nature or are based on an ad-hoc response – without a predetermined plan – when an obligation exists to reduce cost and/or improve the quality of a product or service (Moschuris, 2007). The staff from R&D and quality departments, in addition to those working for controlling and legal departments, should play a relevant role as well (Brem, Gerhard, & Voigt, 2014). After all, the consequences of make-or-buy decisions can determine the firm’s future.

During the last few decades, academic research on make-or-buy has rapidly evolved favoring above all the outsourcing option. Indeed, the extremely fast growth experienced by the make-or-buy research field has hardly left any room for scholars to carry out a global, thorough assessment of the research activity undertaken to date. This article has as its aim not only to provide a more comprehensive historical literature review about make-or-buy decisions, but also to analyze the determinants triggering those decisions within the framework of supply chain management. The goal sought with our work is threefold: examining the extent literature available – insofar as it reveals both past and current trends; identifying possible gaps; and offering potential research opportunities for future researchers. The analysis of the literature will identify the most relevant journals in this area, additionally highlighting

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This is to certify that

Rubén Medina Serrano

has completed the GCU International Doctoral Exchange Week programme

“Should we make or buy? An update and review”

held at Glasgow Caledonian University in conjunction with the University of Alicante and supported by Glasgow School for Business and Society from the 15th to 19th January 2018 from the 15th to 19th January 2018 (40 hours).

Dr Julie McColl/ Dr Lindsey Carey, Exchange Organisers

19th January 2018
10.1.3 Paper 2 (Chapter 4)-Accepted

Apreciada autora:

Nos es grato comunicarle que su trabajo titulado "SUSTAINABLE SUPPLIER EVALUATION PRACTICES ACROSS THE SUPPLY CHAIN" con referencia DyO 18_46 A4 ha sido ACEPTADO definitivamente por el equipo editorial.

Su artículo será publicado en uno de los próximos números de DyO. Le mantendremos informada sobre este asunto.

Reciba de nuestra parte un cordial saludo,

Joaquin Bautista · Editor de DyO · ADINGOR (http://www.revistadyo.es)

El 11/02/2019 a las 14:20, MARIA REYES GONZALEZ RAMIREZ escribió:

Estimado Editor,

muchas gracias, es una estupenda noticia tener el artículo aprobado, 
envío adjunto el mismo sin resaltar en amarillo, y con las ecuaciones con el editor de ecuaciones del word,
Reciban un cordial saludo,

REYES

El lun., 11 feb. 2019 a las 13:07, Joaquin Bautista Valizano (joaquin.bautista@upc.edu) escribió:

Apreciada autora,

Le comunicamos que hemos recibido su trabajo (con correcciones tras Evaluacion 1) titulado "SUSTAINABLE SUPPLIER EVALUATION PRACTICES ACROSS THE SUPPLY CHAIN", cuya REFERENCIA es: DyO_18_46 A4.

El status actual de su artículo es ACEPTADO con pequeña revisión.

Enviaré a Carlos Prado y a mi la versión final, usando su referencia e incluyendo las modificaciones siguientes:

1. Eliminar marcas “amarillas” de resalte de texto.
2. Cambiar las fórmulas (eq.), en modo “gráfico” en su texto actual, por fórmulas escritas con el editor de Word (comando “Insertar_Ecuación”).

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was selected for a poster presentation.

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Your poster is part of the Poster Session. The Poster Session is scheduled for Wednesday, March 20, 2019 from 18:00-19:30. During the Poster Session the authors
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Berlin Acaven <berlin.acaven16@gmail.com> 19 May 2019 at 11:17
To: ruben.medina.serrano@gmail.com

Berlin Acaven <berlin.acaven16@gmail.com> 1:41 PM (3 minutes ago)

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To: ruben.medina.serrano@googlemail.com

19 May 2019 at 11:19

Congratulations!
We are pleased to inform you that your paper entitled “Strategic sourcing: developing a progressive framework for make-or-buy decisions” has been accepted after double-blind peer review by the scientific committee of the OMEACONF, for an Oral presentation. All papers have publication opportunity in a various indexed international journal: Scopus, ISI/Thomson Reuters, DOAJ, Ebsco, Google Scholar, Copernicus, and many more.

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Recommendation to Editors

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This is a well-written article that identifies an important gap.
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Congratulations!

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<td>Originality</td>
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<td>technical merit</td>
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<td>Presentation and English</td>
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<td>Match to Conference Topic</td>
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Recommendation to Editors:

<table>
<thead>
<tr>
<th>Recommendation</th>
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<th>Reject</th>
<th>Marginally Accept</th>
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</thead>
</table>

OMEACONF Organizing Committees
Six Sigma College Düsseldorf

In supplement to certificate no. MBB 3373
this is to certify that

Certified Six Sigma Master Black Belt

Rubén Medina

demonstrated knowledge and skills in compliance with the
Six Sigma College Düsseldorf guidelines for certification and according to the
criteria of the American Society for Quality ASQ in the following topics:

- Six-Sigma roadmap, overview of the DMAIC cycle
- Six-Sigma deployment strategies
- Methodology for the financial evaluation of Six Sigma projects
- Leadership of Six Sigma teams
- Change Management
- Coaching
- Feedback
- Enterprise-wide Planning and Deployment
- Cross-functional Competencies
- Project oversight and management
- Mentoring Responsibilities
- Risk analysis of projects and the pipeline

The training consisted of 22.5 hours of education.

Düsseldorf, 29.03.2019

Helmut Fuchs
Certified SIX SIGMA Master Black Belt

Universitat d’Alacant
Universidad de Alicante
Acceptance letter

2 messages

Berlin Acavent <berlin.acavent19@gmail.com>
To: ruben.medina.serrano@googlemail.com

19 May 2019 at 11:13

Congratulations!

We are pleased to inform you that your paper entitled “How to evaluate sustainable supply chain risks? A case study from the German industry” has been accepted after double-blind peer review by the scientific committee of the OMEACONF, for a Poster presentation.

All papers have publication opportunity in a various indexed international journal: Scopus, ISI /Thomson Reuters, DOAJ, Ebsco, Google Scholar, Copernicus, and many more.

**Please be considered that you can complete your registration process by paying the required fees to confirm your attendance at the conference.

Early registration Round 1 is available until 27 May 2019, late registration is open until 19 August 2019.

The payment can be done through http://www.omeaconf.org/registration/

The conference fee covers all the lunches, program, city tour, conference proceedings, and certificate. If you need a visa for attending the conference, we can provide an official invitation letter from the conference side.

**Please be advised that the Invitation letters are sent only after registration.

Attached, you can find your conference paper review form.

Please don’t hesitate to contact us if we can be of any assistance.

We are looking forward to meeting you at the exciting event in Berlin!

5th international conference on opportunities & challenges in MANAGEMENT, ECONOMICS & ACCOUNTING

29 – 31 August, 2019 Berlin, Germany

Date: 05/19/2019
Number: 504

Review Form of OMEACONF

Paper ID: OMEACONF504
Paper Title: How to evaluate sustainable supply chain risks? A case study from the German industry

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Recommendation to Editors

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</tbody>
</table>
Chapter cited as:
DOI: https://doi.org/10.1007/978-3-658-25188-8_12
Invoice and Registration Confirmation

Dear Mr. Ruben Medina Serrano,

with this letter we would like to inform you that we received your registration for Logistics Management 2019. We confirm that you have registered for the following:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Description</th>
<th>Unit Price</th>
<th>Fee</th>
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<tr>
<td>1</td>
<td>Conference</td>
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Halle (Saale), 19.05.2019
**EXTERNAL ASSESSMENT**
**“DOCTORATE STUDENT”**
(INTERNATIONAL MENTION)

<table>
<thead>
<tr>
<th>A</th>
<th>THESIS</th>
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</thead>
<tbody>
<tr>
<td>Author (Name and surname)</td>
<td>Rubén Medina Serrano</td>
</tr>
<tr>
<td>Title of thesis</td>
<td>Strategic Sourcing Management - A Multiple Criteria Decision Support Methodology with TOPSIS</td>
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<th>B</th>
<th>EXPERT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name and Surname</td>
<td>Prof. Dr. Wanka Welbrock</td>
</tr>
<tr>
<td>University or Research Centre</td>
<td>University of Heilbronn (Campus Schwäbisch Hall)</td>
</tr>
<tr>
<td>Department</td>
<td>Management &amp; Procurement</td>
</tr>
</tbody>
</table>

**C | REPORT**

This report is to confirm that Rubén Medina Serrano, student of the doctorate program “Economy, Society and Enterprise” from the University of Alicante, took part at the Symposium of sustainable procurement celebrated in the Campus Schwäbisch Hall (University of Heilbronn).

Furthermore, during his stay, Rubén Medina Serrano collaborated with the University of Heilbronn in a research work titled "Integration of sustainability aspects in the supplier selection process using the case study of a German industrial firm" (Integration von Nachhaltigkeitsaspekten bei der Lieferantenauswahl am Beispiel eines deutschen Industrieunternehmens). This research work will be released as part of one the University of Heilbronn’s publications.

Universitat d’Alacant
Universidad de Alicante

**Period of stay: From December 2017 till March 2018**

<table>
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<th>D</th>
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W. Welbrock
EXTERNAL ASSESSMENT
DOCTORAL THESIS CONFERRING THE TITLE OF
"INDUSTRIAL DOCTOR"

A   THESIS
Author (Name and surname)
Rubén Medina Serrano
Title provisional of thesis
Strategic Sourcing Management - A Multiple Criteria Decision Support Methodology with TOPSIS

B   EXPERT
Name and Surname / Function
Jürgen Freimüller / Vice President Quality Management
Firm where the Research is developed
R. STAHL Schaltgeräte GmbH
Am Bahnhof 30 74638 Waldenburg | Germany
Department
Quality Management

C   REPORT
Development and creation of the following processes and frameworks:
✓ Sustainable Supplier selection process with its decision matrix tool (FO.DSM-E-071)
✓ Creation of the Code of Conduct for suppliers and third parties (AN.DSM-U-050)
✓ Development of the Supplier self-disclosure (FO.DSM-U-560)
✓ Creation of the Make-or-Buy process with its decision matrix tool (FO.DSM-E-070)
✓ Creation of the Supplier development process
✓ CSR supplier evaluation process (FO.DSM-U-565)
✓ Supply chain design decision process (FO.DSM-U-567)
✓ Sustainable supply chain risk management process (FO.DSM-U-566)
✓ Creation of the Supplier selection requirements matrix (FO.DSM-U-564)

D   SIGNATURE

i. V. Jürgen Freimüller
Leiter Qualitätsmanagement / Vice President Quality Management
R. STAHL Schaltgeräte GmbH
Qualitätsmanagement / Quality Management
Am Bahnhof 30 | 74638 Waldenburg |

Date: 29.01.2019
10.1.13 Verification letter

Michael F. Gorman
INTERFACES
Editor in Chief

Waldenburg
23.10.2018

Unara Zelikovski
CSR Framework
T +49 7942 643-1407
F +49 7942 643-401407

Subject To Whom It May Concern: Providers’ Framework

Dear Professor Gorman,

I am Jürgen Freimüller, Vice President Quality Management at R. STAHL Schaltgeräte GmbH.

My Company is going to use the framework proposed by Ruben Medina-Serrano and coauthors in order to improve the relations with our providers.

Mr. Medina works in our company and has developed this framework as part of his work for the Company but also as part of his research in the external provider area. As far as I know he also is doing a PHD Research in the area of Provider/client relationships at the University of Alicante (Spain).

The main benefits of these frameworks are the development and enhancement of relationships with providers and the management of possible supply chain risks.

Yours faithfully,

Jürgen Freimüller
Vice President Quality Management

SIGNATURE
10.2 Survey

10.2.1 Survey: Best practices on sustainable procurement—(Brainstorming from Chapter 6)

Thank you for helping us to evaluate best practices on sustainable procurement.

Sehr geehrte Damen und Herren,

Guten Tag von R. STAHL,

wären Sie bereit, Lieferantenauswahlverfahren zu Best Practices zur Beschaffung zu bewerten?

In der Lieferkette ist täglich Stau, die Züge sind ständig verspätet: Gehören auch Sie zu den stressgeplagten Controlern?

Guter Lieferant, aber unpassendes Verständnis: Wie können Unternehmen die richtigen Faktoren bei der Auswahl eines externen Anbieters einsetzen?

Für den Lieferantenentwicklungsreport von R.STAHL möchten wir die Best-Practice zur Beschaffung klären und laden Sie herzlich ein, an der Befragung für die Studie teilzunehmen.

Die Umfrage wird lediglich 5-10 Minuten Ihrer Zeit in Anspruch nehmen. Alle Angaben von Ihnen bleiben selbstverständlich anonym.

Als Dankeschön für Ihre Teilnahme werden wir die Ergebnisse der Befragung in den kommenden Monaten den Teilnehmern zukommen lassen.

Die Ergebnisse der Befragung werden nur zu Forschungszwecken verwendet.

Mit den besten Grüßen

Rubén Medina

Dear Sir or Madam,

Good day from R. STAHL,

Would you be prepared to evaluate best practices for supplier selection procedures?

There’s a traffic jam on the supply chain every day, trains are always late: are you one of those stress-prone controllers?

Good supplier, but inappropriate understanding: how can firms use the right criteria when choosing an external supplier?

We would like to evaluate best supplier selection practices for the R. STAHL supplier development report and cordially invite you to take part in the survey for the study.

The survey will only take 5-10 minutes of your time. All information from you will of course remain anonymous.
As a thank you for your participation, we will send the results of the survey to all participants in the coming months.

The results of the survey are only used for research purposes.

With best regards
Rubén Medina
Please answer this question

Thank you very much for answering this questionnaire and helping us to evaluate the intention to adopt efficient supplier selection practices. By answering this survey, you give your permission to use the data you provide to evaluate the supplier selection practice of your choice. This data will only be used for research purposes, and it can be showed or published in any form.

All the data you provide will always be anonymized. You don’t need to provide your e-mail. In case you do, we will be able to send you back the global results of the evaluation.

| How important are the following factors when selecting a key/preferred external provider for your firm? |
|-------------------------------------------------------|-------------------------------------------------|---|---|---|---|
| Company size                                          | High 5                                          | 4  | 3  | 2  | Low 1 |
| Ethical standards                                     |                                                 |    |    |    |       |
| Testing capability                                    |                                                 |    |    |    |       |
| Scope of resources                                    |                                                 |    |    |    |       |
| Technical expertise                                   |                                                 |    |    |    |       |
| Industry knowledge                                    |                                                 |    |    |    |       |
| Commitment to quality                                 |                                                 |    |    |    |       |
| Open to site evaluation                               |                                                 |    |    |    |       |
| Supplier’s process capability                         |                                                 |    |    |    |       |
| Insurance and litigation history                      |                                                 |    |    |    |       |
| References/reputation of supplier                     |                                                 |    |    |    |       |
| Ability to meet delivery due dates                   |                                                 |    |    |    |       |
| Price of materials, parts and services                |                                                 |    |    |    |       |
| Financial stability and staying power                 |                                                 |    |    |    |       |
| Supplier’s effort in eliminating waste                |                                                 |    |    |    |       |
| Honest and frequent communications                    |                                                 |    |    |    |       |
| Flexible contract terms and conditions                |                                                 |    |    |    |       |
| Geographical compatibility/proximity                  |                                                 |    |    |    |       |
| Cultural match between the companies                  |                                                 |    |    |    |       |
| Past and current relationship with supplier           |                                                 |    |    |    |       |
| Supplier’s effort in promoting JIT principles        |                                                 |    |    |    |       |
| Supplier has strategic importance to your firm        |                                                 |    |    |    |       |
| Supplier’s willingness to share confidential information |                                             |    |    |    |       |

### Supplier Selection Criteria

<table>
<thead>
<tr>
<th>Percentage of suppliers work commonly subcontracted</th>
<th>High 5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>Low 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supplier's order entry and invoicing system, including EDI</td>
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<tr>
<td>Your annual orders as a percentage of their overall business</td>
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<tr>
<td>Supplier's ability to make a decent profit for supplying to you</td>
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<tr>
<td>Willingness to integrate supply chain management relationship</td>
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<tr>
<td>Commitment to continuous improvement in product and process</td>
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<tr>
<td>Reserve capacity of the ability to respond to unexpected demand</td>
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<tr>
<td>Compliance with human rights, labor and social legislation</td>
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<tr>
<td>Compliance with environmental and climate protection, and the sustainable management of natural resources</td>
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<tr>
<td>Evaluation of Supplier's Corporate Social Responsibility (CSR)</td>
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</tbody>
</table>

### How important are the following issues when evaluating your key/preferred external providers' performance?

<table>
<thead>
<tr>
<th>Quality level</th>
<th>High 5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>Low 1</th>
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<tr>
<td>Service level</td>
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<td>Correct quantity</td>
<td></td>
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<tr>
<td>On-time delivery</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Price/Cost on product</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Use of electronic data interchange (EDI)</td>
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<tr>
<td>Willingness to share sensitive information</td>
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<tr>
<td>Presence of certification or other documentation</td>
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<tr>
<td>The flexibility to respond to unexpected demand changes</td>
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<tr>
<td>Communication skills (telephone, fax, e-mail, internet)</td>
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<tr>
<td>Quick response time in case of emergency, problem, or special request</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Willingness to change their products and services to meet your changing needs</th>
<th>High 5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>Low 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Willingness to participate in your firm's new products development and value analysis</td>
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</table>

Please indicate the level of your firm's performance compared to that of major industrial competitors in term of:

<table>
<thead>
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<th>Market share</th>
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<th>3</th>
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<th>Low 1</th>
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<td>Return on assets</td>
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<td>Overall product quality</td>
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<tr>
<td>Overall competitive position</td>
<td></td>
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</tr>
</tbody>
</table>

Please indicate your firm's profit as a percentage of sales from last year. Please indicate one of five different profitability/sales ranges:

- □ <0%
- □ 0%
- □ 0 to 5%
- □ 5 to 15%
- □ >15%

Please indicate your firm's R&D investment as a percentage of sales from last year. Please indicate one of five different R&D investment/sales ranges:

- □ 0%
- □ 0 to 5%
- □ 5 to 15%
- □ 15 to 25%
- □ >25%

Please indicate your firm's sales of all sales as a percentage from products introduced in the past four years. Please indicate one of five different ranges:

- □ 0%
- □ 0 to 5%
- □ 5 to 15%
- □ 15 to 25%
- □ >25%

Please select your firm's size (number of employees):

- □ 1-50 employees
- □ 50-100 employees

How important are the following factors when selecting a key/preferred external provider for your firm?

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
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<th>2</th>
<th>Low 1</th>
<th>Response</th>
<th>Average Value</th>
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<tr>
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<td>Company size</td>
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<td>2</td>
<td>1</td>
<td></td>
<td></td>
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<td>3.20</td>
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<td></td>
<td></td>
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<td>13</td>
<td>Price of materials, parts and services</td>
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<td>Financial stability and staying power</td>
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<td>1.90</td>
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<td>15</td>
<td>Supplier's effort in eliminating waste</td>
<td>2 7 1</td>
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<td>1.90</td>
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<td>16</td>
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<td>1.50</td>
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<td></td>
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<td>10</td>
<td>2.50</td>
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<tr>
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<td>Supplier's process capability</td>
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<td>-</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>1.80</td>
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<tr>
<td>22</td>
<td>Insurance and litigation history</td>
<td>2 3 2</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.60</td>
</tr>
<tr>
<td>23</td>
<td>References/reputation of supplier</td>
<td>2 4 2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.40</td>
</tr>
<tr>
<td>24</td>
<td>Ability to meet delivery due dates</td>
<td>6 4</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>1.40</td>
</tr>
<tr>
<td>25</td>
<td>Flexible contract terms and conditions</td>
<td>2 3 5</td>
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<td></td>
<td></td>
<td>10</td>
<td>2.30</td>
</tr>
<tr>
<td>26</td>
<td>Geographical compatibility/proximity</td>
<td>3 2 4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.30</td>
</tr>
<tr>
<td>27</td>
<td>Cultural match between the companies</td>
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<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>10</td>
<td>3.10</td>
</tr>
<tr>
<td>28</td>
<td>Past and current relationship with supplier</td>
<td>1 5 3</td>
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<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.40</td>
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<tr>
<td>29</td>
<td>Supplier's effort in promoting JIT principles</td>
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<td>3</td>
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<td></td>
<td></td>
<td>10</td>
<td>2.60</td>
</tr>
<tr>
<td>30</td>
<td>Supplier has strategic importance to your firm</td>
<td>4 1 4</td>
<td>1</td>
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<td></td>
<td></td>
<td>10</td>
<td>2.20</td>
</tr>
<tr>
<td>31</td>
<td>Supplier's willingness to share confidential information</td>
<td>3 4 2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.10</td>
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<td>32</td>
<td>Percentage of supplier's work commonly subcontracted</td>
<td>2 1 4</td>
<td>3</td>
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<td></td>
<td></td>
<td>10</td>
<td>2.80</td>
</tr>
<tr>
<td>33</td>
<td>Supplier's order entry and invoicing system, including EDI</td>
<td>1 2 4</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td>10</td>
<td>3.10</td>
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<tr>
<td>34</td>
<td>Your annual orders as a percentage of their overall business</td>
<td>1 3 1</td>
<td>4</td>
<td>1</td>
<td></td>
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<td>3.10</td>
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<tr>
<td>35</td>
<td>Supplier's ability to make a decent profit for supplying to you</td>
<td>2 3 2</td>
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<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.60</td>
</tr>
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<td>36</td>
<td>Willingness to integrate supply chain management relationship</td>
<td>1 4 3</td>
<td>2</td>
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<td></td>
<td></td>
<td>10</td>
<td>2.60</td>
</tr>
<tr>
<td>37</td>
<td>Commitment to continuous improvement in product and process</td>
<td>5 5</td>
<td>-</td>
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<td></td>
<td>10</td>
<td>1.50</td>
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<tr>
<td>75</td>
<td>Reserve capacity of the ability to respond to unexpected demand</td>
<td>3 5 2</td>
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<td></td>
<td>10</td>
<td>1.90</td>
</tr>
<tr>
<td>76</td>
<td>Compliance with human rights, labor and social legislation</td>
<td>5 4 1</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>1.80</td>
</tr>
<tr>
<td>77</td>
<td>Compliance with environmental and climate protection, and the sustainable management of natural resources</td>
<td>5 4 1</td>
<td>-</td>
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<td></td>
<td></td>
<td>10</td>
<td>1.60</td>
</tr>
<tr>
<td>78</td>
<td>Evaluation of Supplier's Corporate Social Responsibility (CSR)</td>
<td>3 4 3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td>10</td>
<td>2.00</td>
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</tbody>
</table>
How important are the following issues when evaluating your key/preferred external providers’ performance?

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<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>High 5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>Low 1</th>
<th>Response</th>
<th>Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quality level</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.40</td>
</tr>
<tr>
<td>2</td>
<td>Service level</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.60</td>
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<tr>
<td>3</td>
<td>Correct quantity</td>
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<td>2</td>
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<tr>
<td>4</td>
<td>On-time delivery</td>
<td>7</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.30</td>
</tr>
<tr>
<td>5</td>
<td>Price/Cost on product</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.80</td>
</tr>
<tr>
<td>6</td>
<td>Use of electronic data interchange (EDI)</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>10</td>
<td>3.10</td>
</tr>
<tr>
<td>7</td>
<td>Willingness to share sensitive information</td>
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<td>4</td>
<td>4</td>
<td>1</td>
<td>-</td>
<td>10</td>
<td>2.50</td>
</tr>
<tr>
<td>8</td>
<td>Presence of certification or other documentation</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>-</td>
<td>10</td>
<td>2.60</td>
</tr>
<tr>
<td>9</td>
<td>The flexibility to respond to unexpected demand changes</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>2.00</td>
</tr>
<tr>
<td>10</td>
<td>Communication skills (phone, fax, e-mail, internet)</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.70</td>
</tr>
<tr>
<td>11</td>
<td>Quick response time in case of emergency, problem, or especial request</td>
<td>7</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.30</td>
</tr>
<tr>
<td>12</td>
<td>Willingness to change their products and services to meet your changing needs</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.90</td>
</tr>
<tr>
<td>13</td>
<td>Willingness to participate in your firm’s new products development and value analysis</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>2.10</td>
</tr>
</tbody>
</table>
Please indicate the level of your firm’s performance compared to that of major industrial competitors in term of:

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
<th>High 5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>Low 1</th>
<th>Response</th>
<th>Average Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Market share</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>-</td>
<td>10</td>
<td>2.40</td>
</tr>
<tr>
<td>2</td>
<td>Return on assets</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>2.80</td>
</tr>
<tr>
<td>3</td>
<td>Overall product quality</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>1.70</td>
</tr>
<tr>
<td>4</td>
<td>Overall competitive position</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Please indicate the level of your firm's performance compared to that of major industrial competitors in term of:
Please indicate your firm’s profit as a percentage of sales from last year. Please indicate one of five different profitability/sales ranges:

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>0</td>
<td>0.06%</td>
</tr>
<tr>
<td>2</td>
<td>0%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>3</td>
<td>0 to 5%</td>
<td></td>
<td>4</td>
<td>50.00%</td>
</tr>
<tr>
<td>4</td>
<td>5 to 15%</td>
<td></td>
<td>3</td>
<td>37.50%</td>
</tr>
<tr>
<td>5</td>
<td>&gt;15%</td>
<td></td>
<td>1</td>
<td>12.50%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>8</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Please indicate your firm’s R&D investment as a percentage of sales from last year. Please indicate one of five different R&D investment/sales ranges:

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>2</td>
<td>0 to 5%</td>
<td></td>
<td>6</td>
<td>66.67%</td>
</tr>
<tr>
<td>3</td>
<td>5 to 15%</td>
<td></td>
<td>3</td>
<td>33.33%</td>
</tr>
<tr>
<td>4</td>
<td>15 to 25%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>&gt;25%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>9</td>
<td>100.00%</td>
</tr>
</tbody>
</table>
Please indicate your firm’s sales of all sales as a percentage from products introduced in the past four years. Please indicate one of five different ranges:

| Turnover new products from last 4 years | Total Turnover |

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>2</td>
<td>0 to 5%</td>
<td></td>
<td>4</td>
<td>50.00%</td>
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<td>2</td>
<td>25.00%</td>
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<tr>
<td>4</td>
<td>15 to 25%</td>
<td></td>
<td>2</td>
<td>25.00%</td>
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<tr>
<td>5</td>
<td>&gt;25%</td>
<td></td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>8</td>
<td>100.00%</td>
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</table>

Please select your firm’s size (number of employees):

<table>
<thead>
<tr>
<th>#</th>
<th>Answer</th>
<th>Bar</th>
<th>Response</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-50 employees</td>
<td></td>
<td>2</td>
<td>20.00%</td>
</tr>
<tr>
<td>2</td>
<td>50-100 employees</td>
<td></td>
<td>1</td>
<td>10.00%</td>
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<tr>
<td>3</td>
<td>100-200 employees</td>
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<td>10.00%</td>
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<tr>
<td>4</td>
<td>200-1000 employees</td>
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<td>3</td>
<td>30.00%</td>
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<tr>
<td>5</td>
<td>&gt;1,000 employees</td>
<td></td>
<td>3</td>
<td>30.00%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>10</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Thank you for participating in our survey. Your feedback is important.

A special thanks for your answers. All answers and your special information will be kept confidential unless agreed otherwise. These answers will be part of a global study on user’s expectations and needs.

The study will be published as a book and will be the basis to develop a business plan in order to satisfy customer needs.

I am gathering this information as an independent writer, and publishing the findings in my PhD final project thesis. I do not represent any company or organization.

I am happy to receive any answers, anecdotes or other outsourcing, “make or buy”, related histories via email to Ruben Medina.Serrano@gmail.com

Amables saludos | freundliche Grüße | kind regards | ystävällisin tervetulia

Rubén Medina
Is this model of decision tree applied into your organisation? Which differences/improvements do you face?

Beantwortet: 29   Übersprungen: 1

- Yes: 41.38% 12
- No: 31.03% 9
- Other, please specify: 27.59% 8

Gesamt: 29

Which criteria from the following chart are more relevant at your organization?

Beantwortet: 29   Übersprungen: 1

- #1: Business Strategy
- #2: Product Supply Chain...
- #3: Economic Factors
- #4: Other consideration...

Universitat d’Alacant
Universidad de Alicante
### What of the following considerations are taken into account at your organisation for “Make or Buy” decision?

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Less Relevant</th>
<th>Keine Bezeichnung</th>
<th>Keine Bezeichnung</th>
<th>Keine Bezeichnung</th>
<th>More Relevant</th>
<th>Gesamt</th>
<th>Gewichteter Mittelwert</th>
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<td><strong>Business Strategy</strong></td>
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<tr>
<td><strong>Product Supply Chain Risk to include low quality, reliability, predictability of outsourced solutions</strong></td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td>29</td>
<td>1.34</td>
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<td><strong>Economic Factors</strong></td>
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<td><strong>Other considerations (please specify)</strong></td>
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<td>28</td>
<td>29</td>
<td>1.03</td>
</tr>
</tbody>
</table>
F4 Which factors favoring purchase from outside at your organization?

Which costs for the buy analysis are more relevant at your organization?

Beantwortet: 29  Übersprungen: 1
Which reasons for outsourcing are more relevant at your organization?

Beantwortet: 29  Übersprungen: 1
Which of these stages are applied in the make-or-buy decision process at your organization?
Which financial elements are relevant at your organisation during the "make-it" decision process?

- Activity costs: labour...
- Activity costs:
- Activity costs: raw...
- Invested capital
- Poor information

Which financial elements are relevant at your organisation during the "buy-it" decision process?

- Provider's proposal
- Future pricing in provider's...
- Costs that don't disappear
- One-time costs
- Ongoing costs
- Auditing costs

Link: [https://de.surveymonkey.com/r/VWM8Z5C](https://de.surveymonkey.com/r/VWM8Z5C) (Access on: 26.03.2019)
## 10.3 Supplier assessment process (In-Firm implementation)

### External provider Assessment Process

**Responsible organization:** Firm (DELS)  
**Responsible department:** Purchase  
**Document version:** 1.0  
**Review cycle:** 3 years  
**Process assignment (management system):** Purchase Service

### Distribution list: organizations

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### Distribution list: departments

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<th>Controlling / M&amp;A</th>
<th>Design</th>
<th>Development</th>
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</table>
10.3.1 Scope
This work instruction defines how a supplier is assessed, evaluated and developed as part of the procurement process for all departments of the firm, who participates in the design and/or development of all tooling and/or products and/or services which may require suppliers to be added to company computer system and approved supplier list in SAP. Admittedly, it provides a managerial guideline to help decision managers to, mainly: (1) evaluate new suppliers; (2) determine exactly which products and services to outsource and which kind of Supply Chain Design (SCD) is more suitable; (3) determine the performance expectations by evaluating external providers; (4) use a well-defined professional process to evaluate and select which external providers are more qualified for the job; (5) use a supplier evaluation process to monitor, develop and review supplier risks and supplier performance. The objective is to define the details of the process used by the firm for the assessment of a new supplier.

10.3.2 Authority
Purchasing and SQA are the controlling authority of the process.

10.3.3 Supplier Identification
Where a new supplier has been identified against product/tooling enquiries or where an essential product/process unique to a new supplier is offered to the firm, then Purchasing will request the following information:

1. Full supplier profile
2. Supplier quality manual
3. Supplier self-disclosure form (FO.DSM-U-560)
4. Copies of all appropriate certificates of approval
5. Signed firm’s NDA (Non-Disclosure Agreement) agreement – (where required)
7. Financial report (if required)

It should be noted that a new supplier may already have been identified by Purchasing and/or another department and a signed NDA agreement may already be in existence where the firm owned designs and drawings are involved.
10.3.4 Supplier Review

The originator will complete a supplier application form to be sent to Purchasing/SQA with all accompanying documents, where the application will be logged electronically.

Purchasing, with SQA, will review all supplier supporting documentation, in accordance with the Supplier selection process flowchart (Viflow) to ensure the supplier satisfies all requirements for the product(s)/tooling they have been identified for. Criteria for the evaluation of preferred and second sources can be assessed through the Supplier selection decision matrix (FO.DSM-E-071).

10.3.5 Supplier selection process

The supplier selection process is described in Viflow and drawn in Figure 10-1. A fast track option is available but approval is at the sole discretion of Purchasing and SQA. The supplier application form MUST be completed and the originator should indicate, where stated, that the application is for fast track and provide a full justification for this selection.

It should be noted that support documentation is desirable but not mandatory for a fast track application. However, the originator MUST supply all information requested by Purchasing and/or SQA during the fast track approval process.
10.3.6 Supplier First Evaluation

An initial review of the supplier documentation will be conducted on their history, reliable Corporate Social Responsibility (CSR), good QMS, strong fiscal capability and strong process capability, it will then be determined if a full OA is required.

Should a full OA be deemed necessary, at the sole discretion of SQA, then it will be carried out at the earliest opportunity taking full notice of any expected delivery dates for the product(s)/tooling.

If a full OA is not required, at the sole discretion of SQA, then the process will move to the next step.

A first audit has to verify the skills and capabilities of the potential supplier. All requirements must be fulfilled to meet the specification of the required products.

10.3.7 Supplier Audit

Criteria of the QMS
- Education and Training of Employees
- Process and Documentation of Manufacturing
- Management of Test Equipment
- Function and Hierarchy of Quality Department
- Recording or Sourcing (Sub Supplier(s))
- Process Monitoring
- Manufacturing Process Requirements
- ISO 9001, ISO 80079-34, and certain standards/specifications, involved traceability and CSR criteria (See SAP-Audit questionnaire)

Provision of Documents
- Firm hands over the QAA (Quality Assurance Agreement); e.g. FO.DSM-F-111 Quality Assurance Agreement QAA Cat.1 for catalogue norm parts.
- Firm provides all relevant test specifications and test criteria (FO.DSM-F-090 test plan for suppliers) and is discussing those with suitable examples.

10.3.8 Sample Inspection – First Article Inspection

No. of Samples (Batch Size)

- Batch size of samples can be defined individually based on the required product(s).
- Cross reference with First Sample Release Process – Product Release (AA.DSM-E-300 and AA.DSM-U-065) should be incorporated.
- Required appendices from the initial sample report FO.DSM-E-650 must be selected and provided to the supplier with the initial purchase order (Figure 10-2).
10.3.9 Documents for Approval

- Signed NDA (Non-Disclosure Agreement)
- Signed QAA (Quality Assurance Agreement)
- Signed CoC (Code of Conduct) for Suppliers
- Financial Report

Followed the supplier assessment evaluation based on the supplier selection requirements defined in the FO.DSM-U-564 form. The QAA category is selected according to the product or service characteristics. An overview is drawn in Table 10-1. The QAA process is drawn in Figure 10-5 of Appendix 10.3.22.
Table 10-1. QAA Categories

<table>
<thead>
<tr>
<th>Categories of product requirements (QAA)</th>
<th>Conformity declaration according to ISO 80079-34</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO.DSM-F-111 QAA Cat.1 Catalogue norm part</td>
<td>No</td>
</tr>
<tr>
<td>FO.DSM-F-112 QAA Cat.2 Not Ex drawing part (Design Firm)</td>
<td>No</td>
</tr>
<tr>
<td>FO.DSM-F-113 QAA Cat.3 Licensed parts Ex-relevant (Design external provider)</td>
<td>Yes</td>
</tr>
<tr>
<td>FO.DSM-F-114 QAA Cat.4 Brand labelling (external provider)</td>
<td>Yes</td>
</tr>
<tr>
<td>FO.DSM-F-115 QAA Cat.5 Firm-drawing Ex-relevant (Design Firm)</td>
<td></td>
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<tr>
<td>FO.DSM-F-116 QAA Cat.6 Subcontractors Drawing part Ex (Design Firm)</td>
<td>Yes</td>
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</tbody>
</table>

*Source: own Source*

The Conformity declaration according to ISO 80079-34 is required for products or services with ex-relevant properties and the requirement is marked with “yes” in Table 10-1 above.

### 10.3.10 Documentation for Agreement

The following documents and reports must be submitted:

- ISR Initial sample report according to the FO.DSM-E-650 Initial sample test report
- Verification and validation through provision of objective evidence that specified Firm requirements have been fulfilled
- Material inspection according to EN 10204
- If mechanical parts are machined/coated, the measurement reports must be submitted
- Conformity declaration according to ISO 80079-34

### 10.3.11 Parts and Supplier Approval

All documents and certificates have to be available and checked with a positive result. If the test result meets firm’s requirements, Firm will release the part(s)

In the case where the part does not meet firm’s requirements, the part has to be checked and authorized by firm’s laboratory and/or a 3rd party external inspection partner (see First Sample Release Process – Product Release (AA.DSM-E-300) for more details) before any approval or release is given by the firm.

*Information must be specified in the product requirements.*
After approval and for regular supply of products/components the supplier MUST attach the following documents with their deliveries.

Pre-Despatch Inspection Documents:
- Product Conformity Statement – Where applicable
- Inspection/Test Report – Where applicable
- Material Test Certificate (MTC) – Where applicable
- Material Data Sheet – Where applicable
- Packing List – Where applicable

10.3.12 Statement of Conformity

After the release of a part(s), each delivery of a part(s) must be submitted with a statement of conformity ISO 80079-34 (FO.DSM-F-117 External Providers Declaration of conformity in accordance to ISO 80079-34). With the statement of conformity, the supplier must ensure that all tests have been performed according to the agreement.

10.3.13 Audit Results

SQA will compile and issue their OA report to Purchasing and/or other departments which they deem necessary, which may detail findings from the OA requiring supplier and/or firm inputs/actions to be completed before the supplier can be added to the approved supplier list and used. Audit results are summarized in SAP-Module.

The supplier qualification status procedure is described in the S.O.P. named as “AA.DSM-U-400” and the supplier status category is illustrated in Table 10-2.

Table 10-2. SAP-Status

<table>
<thead>
<tr>
<th>Status Description</th>
<th>Status</th>
<th>EKS</th>
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<tbody>
<tr>
<td>Initial Evaluation / Creation of a vendor master record in SAP</td>
<td>Status 0</td>
<td>EKS</td>
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<tr>
<td>Supplier self-assessment</td>
<td>Status 1</td>
<td>EKS</td>
</tr>
<tr>
<td>NDA, CoC, and approval for order requests</td>
<td>Status 2</td>
<td>EKS</td>
</tr>
<tr>
<td>First visit / Audit, QAA presented</td>
<td>Status 5</td>
<td>EKS</td>
</tr>
</tbody>
</table>
10.3.14 Supplier evaluation and re-evaluation:

Supplier evaluation and re-evaluation is carried out based upon the Supplier Performance evaluation described in the firm procedure named “AN.DSM-U-410 Basis for evaluation document”. The evaluation percentage is drawn in Figure 10-3.

Figure 10-3. Supplier Evaluation

<table>
<thead>
<tr>
<th>Quality</th>
<th>Purchasing</th>
<th>Delivery</th>
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<tbody>
<tr>
<td>40%</td>
<td>20%</td>
<td>40%</td>
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<tr>
<td>80% Complaints</td>
<td>60% Price relationship</td>
<td>75% Adherence to delivery dates</td>
</tr>
<tr>
<td>20% Audit</td>
<td>40% Basis of contract</td>
<td>25% Quantity deviation</td>
</tr>
</tbody>
</table>

Source: AN.DSM-U-410 / Access on 18-02-2019

In the same procedure are described the KPIs for suppliers. An overview is drawn in Table 10-3 and Eq. 9-4.

Table 10-3. KPIs for Suppliers

<table>
<thead>
<tr>
<th>KPI</th>
<th>Description</th>
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| Error rate in % of order positions | Number of the supplier complaints recorded in the reporting period (verbally or written complaint to the supplier regarding to the deviations to the requirements specified in the order) in relation to the delivered order items during the reporting period (goods receipt date) in %.
| Nonconformity rate in % of delivered parts | Number of the claimed parts and devices in the goods receipt department (not compliant quantity) based on the number of all delivered parts and devices during the reporting period in %.
|                | Non-conforming parts:
|                | All parts or devices which do not meet the requirements (order specifications) are recorded detailed in the goods receipt department. |
The encoding (S00*) of non-qualified complaints must be set accordingly in the Q2-complaints.

**10.3.15 Decision Makers**

- Strategic purchaser
- Supplier quality assurance
- Research and development
- Industrial engineer
- Project leader
- Others (e.g. specialist) (see FO.DSM-E-071 doc)

**10.3.16 Supplier development phase**

The objective is to define the details of the supplier development process used by the firm to allow the controlled use of supplier development actions.

**10.3.17 Authority**

Purchasing and SQA are the controlling authority for this procedure.

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6* An adjustment / correction of the reference figure "first confirmed delivery date" is only permitted in the case of the change of the first confirmed delivery date due to explicit customer-request.
10.3.18 Application

The supplier development process is described in Viflow and drawn in Figure 10-4. This process can be used whenever supplier performance is required, especially for suppliers categorized with the note of Supplier B or C. The following actions can be applied in order to improve supplier performance:

- Planning and conducting second party audits
- Requesting Supplier CAPA plan for performing its supplier evaluation
- Performing an internal CSR Supplier evaluation (if required) (FO.DSM-U-565)
- Performing a Sustainable Supply Chain Design Strategy (if required) (FO.DSM-U-567)
- Conducting a Sustainable Supply Chain Risk Assessment to prevent, avoid or mitigate possible shortages in the supply chain (if required) (FO.DSM-U-566)

Figure 10-4. Supplier Development Process

Source: Viflow / Access on 18-03-2019
10.3.19 Responsibilities

The Procurement Head and the SQA Head will ensure that the normal procedure detailed in the aforementioned sections is carried out in line with the relevant section of the supplier development flow chart to ensure full compliance with all requirements. This Assessment considers both tactical and strategic perspectives that link with the corporate strategy and it includes dedicated information on how to set up a Strategic Sourcing function.

10.3.20 Decision Makers

- Strategic Purchaser
- Supplier quality assurance
- Research and development
- Industrial engineer
- Project leader
- Others (e.g. specialist) (see FO.DSM-E-071 doc)

10.3.21 Reference Documents and Records

- FO.DSM-U-560 Supplier Self-disclosure
- AN.DSM-U-050 - Code of Conduct for suppliers and Third Party Intermediaries
- FO.DSM-U-564 - Supplier selection requirements
- FO.DSM-E-071 - Supplier selection decision matrix
- FO.DSM-F-110 Coversheet Quality Assurance Agreement QAA
- FO.DSM-F-111 Quality Assurance Agreement (QAA Cat.1 Catalogue standard parts)
- FO.DSM-F-117 - External Providers Declaration of conformity in accordance with the ISO 80079-34
- FO.DSM-E-650 Initial sample test report
- AA.DSM-E-300 Operational procedure for external procured products and services
- FO.DSM-F-090 - Standardize test plan for suppliers
- AN.DSM-U-410 Basis for Supplier evaluation
- FO.DSM-U-565 - CSR sustainable supplier evaluation practices
- FO.DSM-U-566 - Sustainable supply chain risk management process
- FO.DSM-U-567 – Supply Chain Design decision process
- FO.DSM-E-070 - Make-or-Buy decision process
10.3.22  Appendix

Figure 10-5. QAA-Process

Source: Viflow / Access on 18-02-2019
Follow your heart, love, cry, be smart, be kind
Sei vorsichtig – pero viaja, viaja y viaja –
Pursue your goals, never give up and enjoy the journey!
Choose wisely and don’t forget to give back – Kanpai!
—Rubén Medina Serrano, 21-03-2019—
“hakuna matata inspirations”