Domestic transport infrastructure and firms' export market participation

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Abstract Investment in transport infrastructure reduces the cost of distance and enables firms to establish contacts over larger distances. Using data from a panel of Spanish manufacturing firms and geographic information system techniques, this article studies the impact of domestic transport cost reductions on firms' export market participation, taking into account the role of entry costs and other firm characteristics. We estimate dynamic probability models, controlling for the unobserved heterogeneity of firms and for the simultaneity of firms' export and location decisions. Our results demonstrate a positive effect of domestic transport infrastructure improvements on small and medium-sized firms' probability of exporting.

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1 Introduction

Modern, efficient transport networks are considered essential for international competitiveness, as recognised by the EU policy on trans-European transport networks (European Commission 2009) or the UK Eddington transport study (Eddington 2006). Transport costs are an important part of international trade costs (for a recent review of the role of transport costs in international trade, see, for example, Behar and Venables 2011). Transport infrastructure investment reduces the costs of doing business over distance and thus improves the capacity of firms to compete in global markets. International competitiveness is largely a matter of delivering goods to markets more cheaply than other producers.

The empirical gravity literature has shown a negative relationship between distance and trade flows (for a review, see Disdier and Head 2008), and a positive relationship between the quality of infrastructure and international trade (Bougheas et al. 1999; Limao and Venables 2001). Both distance and infrastructure quality are proxies for transport costs, and it

has been shown that higher transport costs deter trade (Behar and Venables 2011). Overall, falling transport costs have contributed to the increase in international trade over recent decades (Feenstra 1998; Baier and Bergstrand 2001; Behar and Venables 2011). The existing literature on trade, however, has largely focussed on the international dimension of transport costs, while few studies have taken into account the internal geography of countries (Anderson and van Wincoop 2004).

This article contributes to the literature by focussing explicitly on the impact of domestic transport cost reductions on firms' export market participation. While some recent gravity studies of international trade have included, for example, the physical size of countries, population density, or infrastructure measures such as the length of the road network or the number of paved roads to approximate national geography (Redding and Venables 2003; Francois and Manchin 2007; Lawless 2010), these measurements ignore the uneven distribution of exporters within countries (Egger and Egger 2007; Gries et al. 2009). Koenig (2009) and Lafourcade and Paluzie (2011) show how geographic location inside a country is related to the choice of export destination.

Crozet and Koenig (2010) show how internal distances affect exporting.[1] However, the existing empirical literature has not directly tested whether domestic transport infrastructure investment (reducing travel times to export destinations) affects the probability of a firm's entry into exporting. This is important because domestic transport improvements alter the relative internal travel distances to export markets and thus firms' export capacity.

We perform our analysis for Spain, as it is an interesting case. Firstly, since the mid 1980s the country has undertaken massive investments in the national road network, with important financial support from the EU Structural Funds and the Cohesion Fund.[2] No other European country experienced such a rapid expansion of the road network in such a short period of time. While the transport infrastructure network was clearly deficient at the time of Spain's entry into the European Community, today Spain has the largest motorway network among European countries, with more kilometres per capita than France, Germany, the UK, or Italy. We use data from 1990 to 2005. Over this period more than 8,000 km of new motorways were opened to traffic.[3]

Secondly, Spanish transport infrastructure policy is a distinctive case. The principal objective of the motorway building programme was to improve the links between the major cities and facilitate territorial and social cohesion (MOPT 1993). One of the key characteristics of this immense road-building program was that the new motorway corridors closely followed the strongly radial layout of the Spanish road network, dating back to the 18th century. In fact, the historical situation in Spain has been for centuries that principal infrastructure has been built in a star shape, with Madrid in the centre (Bel 2010). This makes the development of the Spanish road network unique, and similar to a pseudo-experimental setting. Bel (2010, 2011) analyses Spanish infrastructure policy over the last three centuries and argues that "transport infrastructure policy in Spain has been driven not by the requirements of commerce and economic activity, but by the desire to centralize the transport system around the country's political capital" (Bel 2011, p. 702). In Bel's view, transport infrastructure development in Spain has been used as an instrument for nation building rather than as a response to economic requirements.

This does not mean that roads have been placed randomly. Road placement is strongly influenced by the physical and economic geography of a country, and by the historic and political situation, as in the case of Spain (see, for example, Bel 2010, 2011 and Holl 2011). Our identification strategy is based on two facts. Firstly, improvements have basically affected all regions, but not all to the same degree. Secondly, the factors which have influenced the placement of new motorways can be viewed as unobservables related to the physical, historical, political, and economic environment existing before the study period, but as largely independent of changes in the economic environment and expected economic growth.[4]

[1] Martínez Zarzoso et al. (2008) control for internal distance to estimate transport costs and their relation to Spanish trade volumes in four sectors.

[2] De la Fuente (2010) provides detailed information on Structural and Cohesion Fund grants for the planning period 2000 2006.

[3] These include free motorways (*autovías*) and toll motorways (*autopistas*).

[4] It is well known, for example, that due to the Expo in Seville in 1992, investment in the Madrid Seville corridor was

Specifically, we control for unobserved time-invariant firm characteristics, which could be potentially correlated with factors influencing road placement.

To date, the issue of transport costs in international trade has largely been analysed in aggregate trade studies. Our article differs by adopting a micro-level approach that allows the analysis of export market participation to be conditional on firms' characteristics. Our empirical strategy combines firm-level data from a panel of Spanish manufacturing firms, and a geographic information system (GIS) analysis to calculate longitudinal data on domestic road travel times to the nearest international border crossing and main seaports based on the real transport network and its improvements.

We use road travel time as a proxy for generalized cost to access export markets. Since land and sea transport are by far the dominant modes of merchandise transportation in Spain, access by road to international border crossings and seaports will account for the majority of variation in the domestic part of transportation costs in exporting. Finding reliable information on transport costs is difficult. Previous studies have often relied on distance as a proxy for transport costs.[5] Given that distance is largely invariant over time, it is essentially a static variable which is unable to link investment in transport infrastructure to transport costs. Moreover, in modern economies where an ever broader range of products is becoming time sensitive, timeliness (and with it, time), rather than simple distance or freight cost, is a key factor in international competitiveness (Evans and Harrigan 2005; Djankov et al. 2010; Behar and Venables 2011).

Using the real transport network and its improvements permits the quality and density of infrastructure to be taken into account, and also directly assesses the impact of domestic transport improvements through travel time reductions, rather than through the effect of location on export participation.

Our empirical strategy exploits the longitudinal structure of our data to control for endogeneity and unobserved heterogeneity among firms. This is particularly important in our case, given that unobserved factors could be correlated with the initial location decision by the firm. Thus, firms with more favourable unobserved characteristics to compete in international markets may be attracted to regions that offer more suitable conditions for exporting. We also account for dynamic effects due to the existence of sunk costs when entering new markets.

Our results provide support for a positive effect of domestic transport infrastructure improvements on small and medium-sized firms' exporting probability. Given the considerable funds allocated to transport investment, it is important to understand the specific mechanisms through which such investment creates economic benefits. Our findings show that transport investment which reduces domestic travel time to international markets can lower threshold costs, to a level where exporting also becomes a viable strategy for smaller firms.

The article is organized as follows. Section 2 provides a review of the related literature. Section 3 describes the data set and presents some descriptive statistics. Section 4 presents the empirical model and estimation strategy. Section 5 reports the results, and Sect. 6 concludes.

2 Related literature

Our research is related to two main strands of literature. On the one hand, we follow the empirical research that studies the determinants of export behaviour at firm level. On the other hand, we are also interested in the effect of reductions in transportation costs. Traditionally this has been studied using aggregate data, but we address this issue from a microeconometric perspective.

2.1 Exports and firm-level characteristics

Starting with the work of Bernard and Jensen (1995, 1999) and Aw and Hwang (1995), a number of recent studies have shown the importance of firm-specific influences on exporting. These micro-level studies emphasize how firm heterogeneity affects participation in international markets. A set of stylized facts

Footnote 4 continued
prioritised, to accommodate traffic arising from the Expo (Royal Decree Law 3/1988), but not because of high expected long term economic growth.

[5] Alternatively, ad valorem transport costs estimated from international trade data have been used, but regional data do not generally allow calculation of domestic ad valorem trans port costs.

about exporting firms has been established. Greenaway and Kneller (2007) and Wagner (2007) provide recent surveys of this literature.

The costs of entry into export markets are found to be a significant determinant of the probability of exporting. Roberts and Tybout (1997) and Bernard and Jensen (2004) test for the possible presence of entry costs by examining the effect of past exports on current exports. They find strong effects of past export experience on the propensity to export. Campa (2004) uses data from Spanish manufacturing firms to analyse the effect of exchange rate uncertainty, and also finds sunk costs to be an important (but independent) factor in determining export market participation.

Export activity has been also related to company size in a number of studies (see, for example, Wagner 1995). In general, export activity is found to be more common among large firms. Larger firms have more resources to access international markets. Given the higher cost of entry to international markets compared to domestic markets, this is argued to make them more likely to be exporters.

Additional determinants of export behaviour are foreign ownership (Roberts and Tybout 1997; Aitken et al. 1997), age and technological factors, such as research and development (R&D) expenditure, innovation or investment in skilled labour (Braunerhjelm 1996; Becker and Egger 2011). Productivity has also received particular attention in empirical studies, which usually find a positive relationship between firm-level productivity and export participation (see, for example, Bernard and Jensen 1995; Girma et al. 2004). Various factors can account for this. First, more productive firms are more likely to be able to absorb the sunk costs associated with foreign market entry. At the same time, international market competition may be fiercer than in domestic markets, meaning that only the most efficient firms can participate (Delgado et al. 2002; Melitz 2003; Bernard et al. 2006, 2007). Alternatively, it has been argued that learning effects associated with exporting could imply that exporting itself makes firms more productive.

2.2 Exports and transport costs

Building on Melitz (2003), Bernard et al. (2006) show in a theoretical model of international trade how falls in trade costs make high-productivity non-exporters more likely to start exporting, and cause existing exporters to increase their exports. An important part of trade costs is transport costs. So far, however, transport costs have been largely ignored by the empirical literature on firms' export decisions. Yet, from the trade literature we know that transport costs matter for international trade. Studies based on the familiar gravity model indicate how the volume of trade between countries rapidly declines with distance (for a recent review, see, Disdier and Head 2008).

As argued by Hummels (1999), distance matters because of transportation costs. Limao and Venables (2001) estimate the elasticity of trade in regard to transport costs and find that a 10-percentage-point increase in transport costs reduces trade volumes by approximately 20%. Distance also has an important effect on the time cost of trade. Anderson and van Wincoop (2004) underline that trade costs are still high even among highly integrated economies and in the absence of informal barriers to trade. They calculate a transportation cost mark-up over production costs of 21% for the USA. Time in transit is increasingly important for modern time-based competitive strategies such as just-in-time production and quick response delivery. Hummels (2001) and Djankov et al. (2010) find that each additional day reduces the probability of trade by 1 1.5%.

Transport costs are not only determined by distance. What also matters is the quality of infrastructure. Bougheas et al. (1999) develop a bilateral trade model with transport costs depending on the level of infrastructure. Infrastructure is shown to raise the volume of trade. Limao and Venables (2001) find that a deterioration of infrastructure from the median to the 75th percentile raises transport costs by 12% and reduces traded volumes by 28%. Using data for sub-Saharan Africa, Redding and Venables (2003) find that poor external geography, poor internal geography and poor institutional quality contribute in approximately equal terms to export performance. Francois and Manchin (2007) show that infrastructure and institutional quality are significant determinants not only of export levels but also of the likelihood that exports take place, and that they are more important than variations in tariffs.

Some indirect supporting evidence on the role of domestic differences in access to export markets is provided by Nicolini (2003). Using a gravity model approach for aggregate trade among European regions, she finds that distance reduces trade while

the density of local transport infrastructure positively affects export flows. Costa Campi and Vildadecans Marsal (1999) study the propensity to export among Spanish municipalities. They find some evidence of a negative effect of distance to the European border and a positive effect for the presence of an international seaport in some sectors. Essentially, few empirical studies have specifically addressed the importance of export market access on firms' likelihood of entry into exporting. These studies have, however, not explicitly considered the effect of transport cost reductions derived from domestic infrastructure improvements, nor have they taken into account unobserved heterogeneity among firms, dynamic effects, and potential problems of self-selection of location.

3 Data and descriptive statistics

3.1 Data

The data for the analysis come from two sources. In the first place, we use a rich data set for Spanish manufacturing firms, the Business Strategies Survey (*Encuesta sobre Estrategias Empresariales*, ESEE). The ESEE, sponsored by the Spanish Ministry of Industry and published by the Fundación Empresa Pública, provides a wide range of information on a sample of more than 4,000 Spanish manufacturing firms, including information on exporting. The survey has been undertaken annually since 1990 and is an unbalanced panel. It was designed with the aim of ensuring representativeness of the Spanish manufacturing sector. At the beginning of the survey, firms with fewer than 200 workers were sampled randomly by industry and size strata, retaining 5%. Firms with more than 200 workers were all requested to participate, and the response rate initially represented approximately a self-selected 60% of firms within this size category (for more details on the survey, see, for example, Fariñas and Jaumandreu 1999). Previous international studies have used the same data set, as it is representative of Spanish manufacturing industry (see, for instance, Campa 2004; Salomon and Jin 2008; González et al. 2005; Ornaghi 2006; Cassiman et al. 2010, among others).[6] We use data for the period from 1990 to 2005. We have eliminated those firms for which relevant information is missing and those companies affected, in the corresponding year, by some process of absorption, merger or split. Our final sample consists of an unbalanced panel of 4,177 firms. In Appendix Table 11 we provide information on the distribution of firms by year and size in our sample. There are between 1,300 and 2,000 firms per year. Approximately half of them are small firms, emphasising the well-known fact that even in the manufacturing sector small firms represent the majority of firms of the Spanish productive system.

In the second place, we use spatially geo-referenced data for the Spanish road network and detailed information from the Ministry of Public Works (Ministerio de Fomento) regarding the opening to traffic of new motorway segments in mainland Spain.[7] This information provides the year a particular link was finished and opened to traffic. This information has been combined with the annual official roadmaps published by the Ministry of Public Works to construct GIS time-series information based on the real evolution of the actual transport network. Next, we related the transport network data to spatially geo-referenced municipality data, in order to calculate an accessibility indicator at the fine-grained geographical level. This accessibility indicator is based on the shortest travel time by road to the closest international border (Portugal or France), or to the closest main seaport and constitutes a proxy for generalized domestic transport costs to access export markets. Road and sea transport account for up to 94% of international goods transport in Spain in terms of quantity and over 80% in terms of value.[8]

Ideally, we would like to have information on the exact location of each firm in the ESEE, but for reasons of confidentiality, such detailed information is not provided. The ESEE only provides location information at the regional level (Autonomous Community), as well as the size (five size categories) of the municipality where the firms' main establishment is

[6] For a complete list of papers using this database, see http://www.funep.es/esee/sp/sesee_articulos.asp.

[7] Given our focus on road infrastructure improvements, we restrict our analysis to the Spanish mainland and exclude Ceuta, Melilla, and the Canary and Balearic Islands.

[8] Alternatively, we have also tested measures of accessibility to main freight transport airports. This is presumably more important for high value or highly perishable goods.

located.[9] In order to link each ESEE firm with the corresponding accessibility data, we calculated the weighted average of accessibility levels for each of the municipality-size categories in each region. Given that several regions have only one municipality in the larger size categories and the fact that firms tend to locate in larger cities, this means that 17.3% of all firms in our sample are matched to the exact municipality accessibility. At the same time, regions tend to have many municipalities in the smallest size categories but few firms in such locations. To assess the bias that could result from this aggregation we compare the mean municipality accessibility with the mean of the region-municipality size category accessibility. Weighted by the frequency of firms in our sample located in the different municipality size categories, the difference is 0.73 min with standard deviation of 4.0 min.

Table 12 in the Appendix presents the definition of the main variables for our study. The choice of variables other than our key dependent variable, the accessibility measure, largely follows the previous literature on the determinants of firms' export decisions. Appendix Table 13 offers information about how industries are classified in our data set.

We have already underlined that firm size has been considered a major source of heterogeneity in export market participation. The rationale is that larger firms may have more resources to access international markets. Given that the entry cost to the international market is higher than that of the home market, this is argued to make them more likely than small firms to be exporters.[10] Government programmes aimed at export promotion have thus often specifically targeted small and medium-sized firms to compensate for their lack of own resources (Fischer and Reuber 2003; Spence 2003). There is now also a growing body of academic literature centred on looking specifically at the entry decisions into foreign markets by small and medium-sized firms (see, for example, Lautanen 2000; Requena 2005; De Clercq et al. 2005; Wright et al. 2007; Ottaviano and Volpe 2011). Regarding our analysis, it may be that the effect of reductions of domestic transport costs on smaller firms' probability of exporting is larger, because reductions in transport costs may lower the threshold costs of accessing international markets to a level where exporting becomes a viable strategy for smaller firms. To control for such different size effects in the coefficients of accessibility, we run separate regressions for three size categories: small (fewer than 50 employees), medium (between 50 and 200 employees) and large firms (more than 200 employees). The threshold of fewer than 50 employees is based on the EU definition for small firms. The large size firm category is only slightly different from the EU classification that defines larger firms as those with more than 250 employees. Here, our threshold is determined by the ESEE sampling criteria explained above.

3.2 Descriptive analysis

Figure 1 shows the percentage, by size, of firms engaged in exporting from 1990 to 2005 in our sample. As documented in the literature, export activity is more common among large firms; compared with firms with fewer than 50 employees, the proportion of

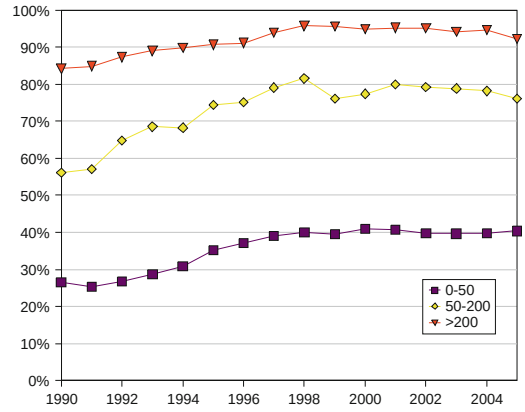

Fig. 1 Evolution of the percentage of exporting firms, by size (number of employees)

[9] Firms could also export from their other establishments. The percentage of multi plant firms is, however, relatively small in our sample. Less than 15% report more than one establishment. Moreover, more than half of these multi establishments have their presence only in one region. Firm relocation could also affect the accuracy of our accessibility measure. However, relocation is not a common phenomenon. Of our sample firms, 97% stayed in the same region over the entire period of analysis, while 93% also stayed in the same municipality.

[10] Small firms may export indirectly by producing intermediate inputs for larger firms that export the final product (Wagner 2001). The ESEE data set does not provide information on such indirect exports. Our results thus only refer to direct exporting activity.

exporting firms is more than double among firms with more than 200 employees.

Overall, the number of exporting firms has increased during this period (from 51% in 1990 to 63.8% in 2005). This increase is sharper among smaller and medium-sized firms; specifically, the percentage of exporting firms among small firms grew from 26.5% in 1990 to 40.4% in 2005. The increase in participation in exporting was especially intense for all types of firms up to 1998 (remaining somewhat stable since then). It should be noted that this coincides with the completion of the main motorway network in Spain. Road infrastructure investment since then has continued the extension of the motorway network but mainly through the construction of a complementary finer mesh network.

Tables 1 and 2 summarize export behaviour in our sample of Spanish manufacturing firms covering the period from 1990 to 2005. Table 1 shows that, over this period, 45% of firms in our sample exported each year, while approximately one-third of firms never exported. There has also been a marked turnover of firms participating in exporting. About 22% of firms showed variation in their export behaviour. Among them, about 35% of these firms started exporting over the period, about 16% stopped exporting and about 49% showed various spells of exporting and non-exporting.

Table 2 provides transition rates into and out of exporting for the firms in our sample. Column 1 indicates the initial export status, and column 2 shows the export status in the following year; for example, in the first row we see that around 90% of firms that did not export in a given year also did not export in the following year, while only a small percentage started exporting. Similarly, for firms that exported, more than 93% of them continued to export in the following year. This shows a high level of persistence in export participation.

Table 1 Export behaviour of firms, 1990 2005

	No. of firms	% of firms
Firms that export in all years	1,620	45.3
Firms that never export	1,172	32.8
Firms that change export behaviour	781	21.9
Start exporting between 1990 2005	273	35.0
Stop exporting between 1990 2005	124	15.9
Stop and start exporting between 1990 2005	384	49.1

Source ESEE

Table 3 provides further descriptive statistics of some key characteristics of firms in our three size categories. Exporters in our sample are on average larger companies. They are also on average older and are more likely to be foreign-owned. Exporters also spend more on R&D and are more likely to introduce both product and process innovations. Exporters in our sample are also more productive than non-exporters in terms of value added per worker. Finally, exporters are on average located closer to international borders and seaports. These descriptive statistics are in line with the previous literature on key differences between exporting and non-exporting firms.

Table 4 shows the percentage of firms that exported according to firm size and sector for our sample covering the period 1990 2005. Export activity is much more common among large firms (more than 200 employees) across all sectors. Nevertheless, while exporting occurs in all manufacturing industries, there are also important differences across sectors in the percentage of exporting firms. Sectors with larger percentages of exporters are leather and footwear, office machinery, data processing, optical equipment, motor vehicles, mechanical equipment, chemical products and metal processing.

Table 5 shows mean domestic travel times to export markets by region at the beginning and at the end of our sample period. It can be seen that travel times have been reduced in all regions, but that regions have also been differentially affected by the transport improvements. This is crucial to identifying the travel cost effect, given that in the estimation we have to control for the upward trend in exports.

Table 6 shows the percentage of exporters according to our accessibility indicators for 1990 and 2005. Here we define areas into high and low accessibility, according to the national average. On average, exporters are closer to the French border and closer to main seaports. However, areas closer to the Portuguese border have fewer exporters than those further away. Overall, this is consistent with evidence found for other countries (see, for example, Lafourcade and Paluzie 2011, for the case of France); i.e., exporters locate closer to international borders. Our estimations take into account this potential self-selection.

Table 2 Transitions in export behaviour of firms (in percentage), 1990–2005

Year t	Year $t+1$	1990–1991	1991–1992	1992–1993	1993–1994	1994–1995	1995–1996	1996–1997	1997–1998
No exports	No exports	91.28	90.08	91.48	91.55	89.04	91.35	88.59	90.31
	Exports	8.72	9.92	8.52	8.45	10.96	8.65	11.41	9.69
Exports	No exports	7.31	4.71	6.42	6.31	3.1	3.74	4.28	4.6
	Exports	92.69	95.29	93.58	93.69	96.9	96.26	95.72	95.4
Year t	Year $t+1$	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	
No exports	No exports	91.34	92.17	94.5	92.78	93.06	97.13	94.27	
	Exports	8.66	7.83	5.5	7.22	6.94	2.87	5.73	
Exports	No exports	4.33	2.88	3.47	3.89	5.19	1.21	1.68	
	Exports	95.67	97.12	96.53	96.11	94.81	98.79	98.32	

Source ESEE

Table 3 Key characteristics of firms

	Small firms (0–50 employees)			Medium sized firms (50–200 employees)			Large firms (>200 employees)		
	Exporters	Non exporters	P value of differences	Exporters	Non exporters	P value of differences	Exporters	Non exporters	P value of differences
Mean number of employees	25.3	19.8	0.00	115.9	100.3	0.00	703.4	459.4	0.00
Mean company age (years)	22	17	0.00	32	28	0.00	39	38	0.49
Mean % of foreign capital	4.4	1.0	0.00	26.7	9.5	0.00	42.7	22.3	0.00
Average R&D expenditure (thousands of euros)	7.6	1.8	0.00	61.1	11.5	0.00	1064.6	145.9	0.00
% of high skill workers	3.3	1.9	0.00	4.2	3.6	0.02	5.2	5.4	0.65
% of medium skill workers	5.1	3.2	0.00	5.6	3.9	0.00	6.1	4.0	0.00
Average value added per employee (euros)	35,344	24,449	0.00	43,578	33,307	0.00	50,819	51,310	0.77
Average general export market accessibility (time in 30 min)	2.4	2.9	0.00	2.7	2.9	0.01	2.3	2.6	0.00

Source ESEE

4 Empirical model and econometric issues

4.1 Empirical model

Our empirical model is based on a simple model of optimisation for a firm facing the export decision. A profit-maximising firm makes its decision based on the expected profits from exporting, now and in the future, taking into account the fixed costs of entering the new market and other variable costs. Roberts and Tybout (1997) develop a model in which a firm exports if the current expected profits Π_{it} (i.e. current period revenues minus current costs) are greater than any sunk costs of entry (S), which depends on previous export

Table 4 Export behaviour by sector, 1990–2005

Sector	% of firms exporting	
	200 and fewer employees	More than 200 employees
Meat products	36.1	84.0
Other food products and tobacco	32.2	92.4
Beverages	51.1	63.9
Textiles	40.8	90.6
Leather and leather products/footwear	57.1	100.0
Wood	34.4	87.5
Paper	52.3	89.1
Printing products	29.2	70.3
Chemical products	63.3	94.5
Rubber and plastic products	53.2	99.9
Non metallic mineral products	33.9	86.7
Basic metals	65.4	94.7
Fabricated metal products	40.9	94.4
Machinery and mechanical equipment	58.4	98.0
Office equipment, precision and optical equipment	61.1	97.7
Electrical equipment	45.8	91.5
Motor vehicles	60.9	97.7
Other transport equipment	49.0	90.0
Furniture	43.4	97.0
Other manufacturing	66.7	98.9

Source ESEE

behaviour. Thus, the export status of firm i in period t is denoted by the binary indicator E_{it}, and so

$$E_{it} = \begin{cases} 1, & \text{if } \Pi_{it} \geq S \cdot (1 - E_{it\ \ 1}) \\ 0, & \text{otherwise} \end{cases}$$

Given the previous theoretical setting, it is possible to derive a reduced-form model to estimate the causal effect of reductions of domestic transport costs on the probability of exporting, while controlling for several other factors that could affect firms' export participation. We empirically model firms' export behaviour as a dynamic discrete choice model with unobserved heterogeneity. On the one hand, it is important to take account of dynamic effects since, as explained above, export decisions depend on past export behaviour, due to the existence of sunk costs when entering new markets.

On the other hand, export decisions are also affected by a number of time-invariant firm-specific characteristics (for instance, product quality or managerial ability) that cannot be directly observed. Lack of control of these unobserved characteristics is known to lead to a "spurious" state dependence in dynamic models (see Heckman 1991), and therefore to biased estimates of any explanatory variable potentially correlated with it. Moreover, it should be noted that transportation costs can also be correlated with time-invariant unobserved heterogeneity through the location decision originally made by the firm. In particular, firms are likely to take into account the geographical advantages of a certain location when planning to engage in exporting.[11] Since our measure of accessibility depends on location, it is potentially correlated with unobserved heterogeneity and, therefore, can be regarded as endogenous.[12]

We characterise the probability of exporting by using the following empirical model:

$$\begin{aligned} &\Pr(E_{it} = 1 | X_{it}, Z_t, E_{it\ \ 1}, \eta_i) \\ &\quad = F(\alpha + \beta X_{it} + \delta Z_t + \theta E_{it\ \ 1} + \eta_i), \end{aligned}$$

where η_i is a time-invariant firm-specific component, X_{it} is a vector of observable variables including accessibility, and Z_t captures the effect of macroeconomic conditions. In Sect. 2 we provide intuitive interpretations for the expected results of the main variables of interest. $F(\cdot)$ is a given function, typically a cumulative distribution function (CDF). For linear models, it is relatively easy to deal with dynamics, with time-invariant unobserved heterogeneity potentially correlated with the explanatory variables, and with the presence of endogenous variables. However, a linear model presents some drawbacks when the dependent variable is discrete; in particular, it does not restrict the predicted values to the (0, 1) interval.

To deal with this we specify $F(\cdot)$ as the CDF of a normal distribution $N(0, 1)$, which ranges between 0 and 1 (probit model). However, given non-linearity, it is more difficult to resolve the above-mentioned econometric issues. Moreover, within the non-linear context, the so-called initial conditions problem must

[11] This issue can also be viewed as a typical initial conditions problem.

[12] Moreover, there are additional sources of endogeneity; for instance, productivity is also likely to be endogenous.

Table 5 Travel time to nearest border and main seaport

NUTS 1 region	Average travel time in minutes					
	1990			2005		
	French border	Portuguese border	Main seaport	French border	Portuguese border	Main seaport
Industrial core areas						
ES5 East	163.4	439.6	58.1	160.4	411.2	55.1
ES2 North East	143.2	307.7	107.8	131.9	289.4	102.6
ES3 Madrid	267.7	193.3	209.1	237.6	180.1	183.4
Periphery						
ES1 North West	321.8	141.9	143.0	282.8	127.3	135.1
ES4 Centre	278.6	172.0	186.5	252.7	157.4	170.3
ES6 South	506.2	220.7	160.4	458.6	190.2	142.0
National	258.6	250.0	143.5	236.4	230.5	131.8

Source GIS own calculation

Table 6 Percentage of exporting firms by accessibility level

	High accessibility areas[a]		Low accessibility areas[a]	
	1990 % exporters	2005 % exporters	1990 % exporters	2005 % exporters
According to:				
Travel time to French border	55.3	68.5	42.5	56.6
Travel time to Portuguese border	40.3	57.0	54.2	68.3
Travel time to main seaports	51.7	66.4	40.9	57.3
Travel time to border/seaport	50.6	65.9	44.4	58.0

Source ESEE, GIS own calculation

[a] High (Low) accessibility areas include those regions above (below) the national average accessibility that year

be controlled for. The idea is that the initial observation period does not correspond with the first period the firm is in the market. The beginning of the process is unobserved for the econometrician and possibly correlated with the unobserved effects. This problem does not appear in the linear case, since the unobserved effects can be ruled out by a simple transformation of the model. However, no general transformation which would eliminate the unobserved effects in non-linear models is known.

4.2 Estimation strategy

We follow a progressive estimation strategy, in the sense that we estimate a sequence of models to address the pertinent econometric issues in different steps. Our analysis begins with the estimation of models that treat all explanatory variables as strictly exogenous and neglect both unobserved heterogeneity and endogeneity issues (pooled probit model). Such estimations are likely to be biased, and the results should only be taken as benchmarks, since it is difficult to infer causal effects from them.

Unobserved heterogeneity: We exploit the longitudinal information in our data to control for firms' unobserved heterogeneity, which is potentially correlated with the explanatory variables. We estimate a correlated random-effects probit model following the approach proposed by Chamberlain (1980).[13] Specifically, we assume a reduced form for unobserved heterogeneity, as a function of the time average of all

[13] A random effects approach (RE probit) can also be employed; this assumes that the company effects are uncorrelated with the explanatory variables. Nonetheless this assumption is quite likely violated in our export decision model, as plant characteristics are correlated with unobserved product attributes, managerial ability, technology and other unobserved plant effects which may affect the company's decision to export.

the explanatory variables (except the lagged endogenous variable):

$$\eta_i = \pi \overline{X}_i + \zeta_i,$$

where ζ_i is normally distributed and, by definition, independent from X_{it} and ε_{it}. Then, this reduced form can be inserted into the main equation for the probability of exporting, to perform a standard random-effects probit.

By allowing the time-invariant firm-specific component η_i to be correlated with the location-based accessibility variable, we are controlling for the potential self-selection of exporters into regions with better access to export markets.

Dynamic effects and endogeneity issues: To further control for the fact that the lagged export decision cannot be considered as strictly exogenous, we follow Wooldridge's (2005) approach and model the unobserved heterogeneity conditional on the initial condition, E_{i0}, and the exogenous variables.[14] The likelihood of interest has the same structure as in Chamberlain's approach to static models, except that the reduced form for unobserved heterogeneity also includes the initial observation of the dependent variable:

$$\eta_i = \gamma \overline{X}_i + \varphi E_{i0} + \xi_i.$$

This approach accounts for the correlation between E_{it-1} and η_i; this is particularly important in our case since initial firm location is potentially correlated to both export market participation and accessibility.

5 Results

The estimation results are presented in Tables 7, 8, and 9, for the different models described in the previous section. We present estimation results for each of the three firm size categories, given the specific relevance of firm size heterogeneity in both the academic literature and for policymaking.

All specifications include time dummies to control for the business cycle and any other common time trends and factors affecting export behaviour in general.[15] It should be noted that during our sample period there was a general increase in exports, due to the greater openness of the Spanish economy to international markets. Therefore, lack of control for aggregate conditions could be spuriously captured by some other variable, in particular our measure of infrastructure improvements.

5.1 Pooled estimates

Table 7 presents the estimation results from pooled probit models. In these estimates lagged export status is treated as exogenous. Similarly to previous studies, we find that state dependence is very important in the export decision: the parameter for previous export experience is strongly positive and significant in all our estimates.

In Table 9, we report the marginal effect of lagged export status and find that for small and medium-sized firms the probability of exporting increases by around 80% if the firm was exporting the previous year. For large firms the probability of exporting increases by around 70%. Although the coefficients in these estimates are most likely biased, this finding supports the hypothesis that there are significant sunk costs involved in entering export markets and, as we expected, sunk costs have a smaller effect on larger firms.

Additionally, we find that the effect of accessibility on export participation is indeed different for firms of different size. Specifically, it is significant for small firms, marginally significant for medium-sized firms and insignificant at the standard levels for larger firms.[16] In terms of the marginal effect, Table 9 shows that a reduction of 30 min in accessibility time increases the probability of exporting by around 1% and 0.7% for small and medium-sized firms, respectively.[17] These results show that time is a relevant competitive factor and that domestic transport costs

[14] An alternative approach would consist of specifying the joint distribution of all outcomes conditional on unobserved heterogeneity. This approach has the practical problem of being unable to establish the conditional distribution of the initial condition. Heckman (1981) proposed approximating such a conditional distribution, although this solution is computationally cumbersome.

[15] Such as, for example, the introduction of the euro in 2002.

[16] It should be underlined that, since our analysis is conditional on company size and we have a representative sample of firms with sufficient variability, the estimated effect of the variables of interest for each size group can be interpreted as a ceteris paribus effect. Consequently, our results are not driven by a size effect.

[17] In an alternative estimation, we included as an additional regressor the interaction between our measure of road improvements and the lagged dependent variable, but did not find a statistically significant effect.

Table 7 Estimation results of probit pooled model, by size

	Pooled probit		
	0 50	50 200	>200
EXPORT(1)	2.7204***	2.8596***	3.0460***
	(0.0394)	(0.0775)	(0.0973)
ACCESSIBILITY	0.0324***	0.0366*	0.0078
	(0.0101)	(0.0189)	(0.0231)
R&D(1)	0.1868***	0.2623***	0.0720
	(0.0566)	(0.0870)	(0.0958)
PRODUCTIVITY(1)/10^6	7.1159***	0.4048	0.0965
	(1.0713)	(1.6820)	(0.3645)
HIGH SKILL(1)	0.0084**	0.0024	0.0029
	(0.0035)	(0.0080)	(0.0063)
MED SKILL(1)	0.0047*	0.0039	0.0122
	(0.0026)	(0.0071)	(0.0084)
AGE/10	0.0085	0.0603	0.0682
	(0.0245)	(0.0369)	(0.0430)
AGE2/100	0.0014	0.0032	0.0025
	(0.0024)	(0.0028)	(0.0033)
SIZE/100	3.0776***	0.3527	0.0231
	(0.7707)	(0.5379)	(0.0206)
SIZE2/10000	3.2049**	0.2487	0.0001
	(1.4675)	(0.2276)	(0.0006)
FOREIGN(1)	0.0002	0.0018	0.0018
	(0.0014)	(0.0011)	(0.0011)
SPILLOVER (DOM.)	0.0391	0.0020	0.2144
	(0.0715)	(0.1362)	(0.1754)
SPILLOVER (MUL.)	0.0237	0.0816	0.4228
	(0.2258)	(0.4495)	(0.5003)
TIME DUMMIES	Yes	Yes	Yes
INDUSTRY DUMMIES	Yes	Yes	Yes
Number of observations	10,404	3,695	5,752
Number of firms	1,520	719	903

Robust standard errors in parenthesis. Significant coefficients are indicated by ***, **, *, for significance at the 1%, 5% and 10% level, respectively

affect the ability of small and medium-sized firms to enter export markets.

The finding of a differential impact among firms of different size also makes sense. It shows that transport infrastructure improvements can indeed reduce the cost of accessing international markets to a level at which exporting becomes profitable for some smaller firms. This is important since smaller firms are precisely those often targeted by export promotion programmes.

By contrast, large firms do not seem to be significantly induced to export by reductions in domestic transport costs. Many of them export anyway; in our sample over 75% of large firms exported in all years. Furthermore, they may also be more concerned about other internalization strategies, such as locating production abroad through foreign direct investment (FDI) or joint ventures.

Because our measure of accessibility is based on the real road network and its improvements, the results show that public infrastructure investment which reduces domestic transport costs can facilitate trade in goods, not only within countries, but also by increasing firms' propensity to export through reducing the domestic part of transport costs in international trade. Traditionally, international trade has been

Table 8 Estimation results of probit models with unobserved firm effects, by size

	CRE probit			CRE probit with IC		
	0 50	50 200	>200	0 50	50 200	>200
EXPORT(1)	2.6031***	2.8417***	3.0887***	1.9762***	2.2612***	2.6805***
	(0.0567)	(0.0786)	(0.1017)	(0.0668)	(0.1164)	(0.1291)
ACCESSIBILITY	0.0200	0.0829**	0.0382	0.0587	0.1117**	0.0068
	(0.0285)	(0.0391)	(0.0524)	(0.0411)	(0.0503)	(0.0628)
R&D(1)	0.2132***	0.2585***	0.0592	0.2074***	0.2888***	0.0398
	(0.0642)	(0.0879)	(0.0987)	(0.0791)	(0.1079)	(0.1148)
PRODUCTIVITY(1)/10^6	7.7889***	0.4597	0.0978	8.5533***	1.2021	0.1627
	(1.2267)	(1.7147)	(0.3525)	(1.5023)	(2.0567)	(0.3599)
HIGH SKILL(1)	0.0105***	0.0034	0.0025	0.0095*	0.0008	0.0001
	(0.0040)	(0.0081)	(0.0065)	(0.0052)	(0.0103)	(0.0074)
MED SKILL(1)	0.0063**	0.0033	0.0114	0.0086**	0.0017	0.0102
	(0.0030)	(0.0073)	(0.0088)	(0.0036)	(0.0090)	(0.0095)
AGE/10	0.0119	0.0570	0.0637	0.0499	0.0597	0.0496
	(0.0296)	(0.0381)	(0.0458)	(0.0441)	(0.0510)	(0.0538)
AGE2/100	0.0017	0.0029	0.0021	0.0024	0.0038	0.0021
	(0.0029)	(0.0029)	(0.0035)	(0.0044)	(0.0039)	(0.0042)
SIZE/100	3.7231***	0.3149	0.0220	4.8481***	0.4945	0.0261
	(0.9070)	(0.5441)	(0.0208)	(1.1734)	(0.6618)	(0.0161)
SIZE2/10000	3.7513**	0.2398	0.0001	4.6534**	0.3279	0.0001
	(1.6852)	(0.2297)	(0.0005)	(2.1773)	(0.2792)	(0.0001)
FOREIGN(1)	0.0008	0.0013	0.0013	0.0006	0.0002	0.0013
	(0.0017)	(0.0011)	(0.0012)	(0.0024)	(0.0014)	(0.0014)
TIME DUMMIES	Yes	Yes	Yes	Yes	Yes	Yes
INDUSTRY DUMMIES	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	10,284	3,666	5,688	10,284	3,666	5,688
Number of firms	1,509	716	903	1,509	716	903

IC initial conditions, *CRE* correlated random effects

Robust standard errors in parenthesis. Significant coefficients are indicated by ***, **, *, for significance at the 1%, 5% and 10% level, respectively

Spillover effects have been dropped in these estimates due to multicollinearity

analysed as taking place between countries, abstracting from internal geography. Our results also show that the internal geography of countries, which is shaped by transport infrastructure investment, matters.[18]

Other company characteristics have, in general, the expected effect on the probability of exporting, although their significance varies according to the model considered; for example, firms which perform R&D activities are more prone to exporting. Productivity also increases the probability of exporting, but we find that this effect is only significant for small

[18] Our results could be refined if we had information on the export destination markets of firms. Unfortunately, the information provided in the ESEE survey is too aggregate and does not provide information on transport modes to calculate destination specific accessibility measures. Nevertheless, we performed separate estimates where we distinguished between EU, other Organisation for Economic Co operation and Development (OECD) countries, and the rest of the world. As expected, our results are more imprecise but qualitatively similar, especially those related to EU export markets, since this is the most important export destination. These estimates are available upon request.

firms. Similarly, the skill composition of the workforce turns out to be significant only for small firms. Our results also show the usual inverted U-shaped relationship between the size of the firm and its export participation. Company age, foreign ownership of the firm, as well as spillovers in the export decision stemming from the presence of other domestic or multinational exporters show no significant effect.

5.2 Control for unobserved heterogeneity and dynamics

Table 8 presents estimations that control for unobserved heterogeneity of firms in our three size categories. The first three columns present the estimates from a correlated random-effects probit model, which treats lagged export behaviour as exogenous (Chamberlain's approach). Estimated coefficients for lagged export status and accessibility are similar to those obtained in the pooled model. Once we control for the endogeneity of past export behaviour and estimate the CRE probit model with initial conditions (columns 4 6), the marginal effect of this variable is reduced; specifically, exporting in the previous year increases the probability of exporting the next year by around 60% for small and medium sized-firms and 40% for larger firms (Table 9).

Regarding the effect of accessibility, again we find no significant effect for larger firms, but the significant effect for medium-sized firms is confirmed, with a marginal effect of around 1.5%.

5.3 Robustness checks

We have performed several additional estimates to check if our results are robust to changes in the sample, to the definition of certain variables and to other econometric issues.

First of all, we performed a set of generalized method of moments (GMM) estimates in a linear model, to account for the potential endogeneity of explanatory variables other than lagged export status. In the linear context, unobserved heterogeneity can be differenced out, thus solving any endogeneity caused by the correlation between the unobserved heterogeneity and the explanatory variables. Then, potentially predetermined variables (that is, contemporaneously endogenous with respect to the time-varying error term) can be instrumented using lagged values (see Anderson

Table 9 Estimated marginal effects from non-linear models

	Pooled probit			CRE Probit			CRE probit with IC		
	0–50	50–200	>200	0–50	50–200	>200	0–50	50–200	>200
EXPORT(−1)	0.8238***	0.8037***	0.6980***	0.8018***	0.7985***	0.6637	0.6508***	0.5934***	0.4324
	(0.0067)	(0.0155)	(0.0335)	(0.0110)	(0.0163)	(2117.1000)	(0.0199)	(0.0494)	(54.8910)
ACCESSIBILITY(−1)	−0.0115***	−0.0072*	0.0002	−0.0070	−0.0161**	0.0008	−0.0195	−0.0166**	−0.0001
	(0.0036)	(0.0037)	(0.0007)	(0.0100)	(0.0076)	(11.7380)	(0.0137)	(0.0075)	(0.0307)

Robust standard errors in parenthesis. Significant coefficients are indicated by ***, **, *, for significance at the 1%, 5% and 10% level, respectively

and Hsiao 1982; Arellano and Bond 1991). In addition to firms' past export behaviour, we treat firms' R&D expenditure, productivity and employee skills as potentially endogenous (see Table 10) and instrument first differences with their lagged values in period $t-3$ and before.[19] However, this strategy does not allow us to identify the effect of accessibility, due to insufficient "within" variability of this variable in our sample. This parameter must then be identified in the equation in levels, but since accessibility is correlated with the unobserved heterogeneity through the original location decision made by the firm, we need an instrument.

As discussed earlier, there exists empirical evidence that infrastructure improvements in Spain have not been concentrated in specific regions or locations where economic growth was expected to occur (see for instance Bel 2010, 2011) and thus where greater export market participation was expected to occur. Holl (2011) estimates the probability of a municipality receiving a new motorway within the radius of its municipality, and shows that the single most important factor has been the existence of a major trunk road in the vicinity of the municipality. Previous economic growth in the area shows no significant relation to receiving a new motorway once other factors are controlled for. Our GMM estimations exploit this by using changes in accessibility as a valid instrument for the equation in levels. In particular, we use this change in period $t-2$ as an instrument for the level equation, in order to avoid potential endogeneity (with respect to the time-varying error term) due to measurement error in our measure of accessibility.[20]

The estimated effect of neither the lagged export decision nor of these endogenous explanatory variables was significantly affected once the endogeneity of these variables has been controlled for.[21] Regarding accessibility, our previous qualitative result, i.e. that infrastructure improvements increase the likelihood of exporting for small and medium-sized firms, is reinforced. Although the point estimates are smaller, we still find that when time is reduced by 30 min their probability of exporting increases by 0.75%.

In the last rows of Table 10, we show tests that are unable to reject the validity of the estimated model (i.e. that the specification and the instruments used are correct). However, one potential problem with GMM estimates comes from the so-called weakness of instruments when using too many lags of the endogenous variables as instruments. Our results remain unchanged when GMM estimates were performed using lagged values in period $t-3$ only (but not before) as instruments.[22]

One of our main concerns is to account for the possibility of self-selection of exporters. The CRE model and CRE with initial condition in Table 8 control for self-selection caused by time-invariant unobservable characteristics that affect both location choice and export participation. Firms that started exporting, could, however, also have moved to certain regions where the transport infrastructure has improved. We therefore estimate our benchmark model using only those firms that were present in 1990 and founded before 1980. In this group of firms, location can be regarded as independent of later motorway improvements. This set of results is qualitatively not very different from the one presented here and confirms a significant effect, especially for medium-sized firms.[23]

Our principal results also remain unchanged following other robustness checks. All estimations have been performed, using not only value added per worker as a measure of productivity, but also using an alternative definition: sales per worker. It is well known that in the period considered there has been a spread in the use of outsourcing by many firms. Added value might be distorted to the extent that this outsourcing process affects not all industries and firms in the same way.

[19] Notice that we could in principle use lagged values in $t \quad 2$ as instruments. However, it is preferable to use longer lags as there is some evidence of (weak) second order correlation in the first differenced error term, according to the m2 statistic in Table 10.

[20] It should be noted that this is not exactly the so called GMM system, first developed by Arellano and Bover (1995). We combine both information in first differences and information in levels, but in our case the latter does imply additional moment conditions (the validity of which can be tested). Specifically, the parameter of the accessibility variable can only be identified from the moments that use information in levels.

[21] Since the level of aggregation of the accessibility variables is higher than that of the dependent variable, using clustered standard errors would appear to be a possibility. However, their use in dynamic models estimated by GMM might lead to unreliable results when the number of clusters is low, as in our case (see Roodman 2006). Thus, we report robust standard errors that in turn could be downward biased, if the within cluster correlation was negative (which is not a priori clear).

[22] This type of estimates follows Anderson and Hsiao (1982).

[23] Results are available upon request.

Table 10 GMM estimation results of linear models, by size

	0 50	50 200	>200
EXPORT(1)	0.8552***	0.7945***	0.6395***
	(0.071)	(0.066)	(0.072)
ACCESSIBILITY	0.0075*	0.0072**	0.0005
	(0.004)	(0.004)	(0.002)
R&D(1)	0.0451	0.0078	0.0022
	(0.056)	(0.032)	(0.010)
PRODUCTIVITY(1)/10^6	1.1142	0.0551	0.1204
	(1.366)	(0.311)	(0.109)
HIGH SKILL(1)	0.0014	0.0015	0.0008
	(0.003)	(0.001)	(0.001)
MED SKILL(1)	0.0004	0.0002	0.0000
	(0.002)	(0.001)	(0.000)
AGE/10	0.0015	0.0771	0.004
	(0.045)	(0.077)	(0.027)
AGE2/100	0.0067	0.0671	0.0001
	(0.004)	(0.074)	(0.021)
SIZE/100	0.2563**	0.0173	0.0001
	(0.106)	(0.048)	(0.000)
SIZE2/10000	0.1137	0.0017	0.0000
	(0.187)	(0.017)	(0.000)
FOREIGN(1)	0.0000	0.0002	0.0001*
	(0.001)	(0.000)	(0.000)
SPILLOVER (DOM.)	0.0028	0.0014	0.0067
	(0.009)	(0.013)	(0.005)
SPILLOVER (MUL.)	0.0129	0.0099	0.0144
	(0.027)	(0.032)	(0.018)
TIME DUMMIES	Yes	Yes	Yes
INDUSTRY DUMMIES	Yes	Yes	Yes
Number of observations	10,284	3,666	5,688
Number of firms	1,509	716	903
m1	9.394***	6.377***	5.541***
m2	1.351	1.772*	2.229**
m3	0.0955	1.515	0.813
Hansen test of overidentification (*P* value)	108.6	108.8	89.97
	(0.624)	(0.619)	(0.953)

Robust standard errors (from second step GMM estimation) in parenthesis. Significant coefficients are indicated by ***, **, *, for significance at the 1%, 5% and 10% level, respectively

We use the following instruments: export behaviour, R&D expenditure, productivity and labour skills lagged *t* 3 and before in the first differenced equation, and changes in accessibility dated *t* 2 for the equation in levels. All the remaining variables are regarded as exogenous

The statistics m1, m2 and m3 test for autocorrelation of order 1, 2 and 3, respectively, and follow an standard normal distribution. The Hansen statistic follows a chi squared distribution with 114 degrees of freedom

Our results are similar using either definition of productivity, suggesting that the measure of productivity based on value added is not affected by this issue.

The inclusion of time dummies in our current specification already accounts for the effect of exchange rates, and also allows for a degree of firm heterogeneity, since we perform separate regressions by size. Following the literature (for instance, Campa 2004), we nonetheless considered specifications which include exchange rates instead of time dummies. We constructed individual exchange rates taking into account specific export destinations for each firm. We did not find any significant effect of this variable. This result could be due to the fact that the EU is by far the most important destination for almost all exporting firms in our sample.

We were also concerned with firms whose change in size moves them to a different size category. Overall, more than 85% of firms in our sample never change their size category, but medium-sized firms are more likely to be affected. Therefore, we performed

our analysis after redefining the medium-sized category to avoid firms entering and leaving systematically; in particular, we classify as medium-sized firms those with between 75 and 175 employees. Although slightly more imprecise (due to the reduction in sample size), the estimated effects were very similar to those presented here.[24]

Finally, our estimates could be biased if roads were significantly improved in areas where economic growth was expected to take place, but as previously pointed out, some authors provide empirical evidence that this has not been the case in Spain (see Bel 2010, 2011; Holl 2011). Nonetheless, we also performed a set of GMM estimates which control for regionally specific time trends.[25] None of the variables (even the lagged dependent variable) were significant, but the magnitude of the estimated coefficients remained unchanged. This suggests that omitted variables at the regional level are not causing serious bias in our previous results, although the lack of variability in the data does not allow us to identify all the effects, once too many of those regional explanatory variables are included.

6 Conclusions

In this article we have analysed the probability of firm entry into exporting by focussing on the role of domestic road transport cost reductions, and also taking into account the effect of sunk costs and other company characteristics. While trade costs are central to trade theory, the specific role of domestic transport cost reductions in firms' export participation decisions has not been analysed in the empirical microeconomic trade literature.

We have followed a progressive estimation strategy, trying to overcome different econometric problems which could prevent us from obtaining a true causal effect of the variables of interest. Our preferred estimates are those which take into account unobserved heterogeneity, initial conditions, lack of exogeneity of past export behaviour and other endogeneity issues.

In line with previous literature, we find that a number of company characteristics, in addition to entry costs, are important in determining the propensity to export. Our results underline that there exist differences in thresholds to export market entry, conditioned by company size. While traditional trade models have typically abstracted from countries' internal geography and thus differences in domestic transport costs acting as a barrier to export, we find a significant effect on the probability of exporting. In particular, when road accessibility time to international markets is reduced by 30 min, the probability of exporting increases by between 0.5% and 1.5% for smaller firms (those with 200 or fewer employees).

To put these figures into perspective, we have carried out some "back of the envelope" calculations based on our preferred model. Transport infrastructure improvements between 1990 and 2005 accounted for approximately 3% of the total increase in the proportion of small firms which exported over this period, and approximately 1% in the case of medium-sized firms. This figure may seem small, but it should be noted that this period is characterized by an important increase in the openness of the Spanish economy. Moreover, these figures must be seen as a lower boundary since our model accounts for the time trend, which may capture part of the effect.

As the international environment is becoming more competitive and faster paced, issues of access are likely to become more important. In the face of the increasing fragmentation and globalisation of production, poor domestic transport links can constitute an important obstacle to participation in global production networks which rely heavily on speed across global space.

Our results have interesting policy implications. There is empirical evidence to show a positive effect of export promotion agencies and their activities on aggregate trade flows (Rose 2007; Segura-Cayuela and Vilarrubia 2008), as well as on the number of countries reached by existing exporters and the number of products traded (Volpe and Carballo 2008, 2010). However, those studies focussing specifically on the probability of firms engaging in exporting to date have found no significant effect of state expenditure on export promotions (see Bernard and Jensen 2004; Görg et al. 2008). Our findings suggest that infrastructure improvements could be more successful in helping at least small and medium-sized firms to start exporting.

[24] We also check whether our results are affected by the fact that we use an unbalanced panel. This concern mainly applies to the non linear estimates, since the CRE methods were originally developed for balanced panels. However, our sample size is reduced dramatically when restricted to a balanced panel. This produces very imprecise estimates of the parameters of the model.

[25] These estimates are available upon request.

Our results could be particularly useful for developing countries seeking to promote trade, since they typically possess poor domestic transportation infrastructure and are also far from key international markets. Our results also have implications for regional development in general. They show one way in which domestic transport cost differences can affect economic geography within countries.

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Appendix

See Tables 11, 12, and 13.

Table 11 Number of firms, by size and year

	Size (number of employees)			Total
	0 50	50 200	>200	
Total num. firms	2,014	950	1,213	4,177
Total num. obs. by year	13,812	4,777	8,457	27,046
1990	947	253	663	1,863
1991	1,016	268	725	2,009
1992	1,006	261	637	1,904
1993	964	267	507	1,738
1994	886	274	549	1,709
1995	835	274	514	1,623
1996	878	281	483	1,642
1997	967	358	486	1,811
1998	866	335	464	1,665
1999	873	356	453	1,682
2000	855	331	577	1,763
2001	801	309	496	1,606
2002	801	331	512	1,644
2003	633	255	423	1,311
2004	628	256	422	1,306
2005	856	368	546	1,770

Source ESEE

Table 12 Definition of variables

Variable	Definition
EXPORT	Indicator for firm's export activity (= 1 if firm exports)
ACCESSIBILITY	Shortest travel time to nearest international border or main seaports (time in 30 min)
R&D	Indicator for firm's R&D activity (= 1 if firm hires or carries out R&D activities)
PRODUCTIVITY	Value added over number of employees
HIGH SKILL	Percentage of workers with a university degree
MED. SKILL	Percentage of workers with a high school degree
AGE	Years since firm's foundation
SIZE	Total number of employees
FOREIGN	Percentage of foreign capital
SPILLOVER (DOM.)	(Exports by domestic firms in sector *j*/ total exports in *j*)/(total exports by domestic firms/total exports)
SPILLOVER (MUL.)	Same as above for multinational firms

Table 13 Classification of industries in ESEE

(1)	Meat products
(2)	Other food products and tobacco
(3)	Beverages
(4)	Textiles
(5)	Leather and leather products/footwear
(6)	Wood
(7)	Paper
(8)	Printing products
(9)	Chemical products
(10)	Rubber and plastic products
(11)	Non metallic mineral products
(12)	Basic metals
(13)	Fabricated metal products
(14)	Machinery and mechanical equipment
(15)	Office equipment, precision, optical equipment
(16)	Electrical equipment
(17)	Motor vehicles
(18)	Other transport equipment
(19)	Furniture
(20)	Other manufacturing

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