# The life cycle of exporting firms*

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**Abstract**

We use detailed micro data from the Portuguese manufacturing sector to study the evolution of export performance over the firm life cycle. We find that, as firms age, the distributions of employment, export revenue, number of destinations and exported products shift progressively to the right. We also show that market selection based on initial size or export performance plays a minor role in explaining this evolution; and that, as firms grow older, they tend to pay higher wages, import more expensive inputs, and charge higher prices for exports, especially in sectors with greater scope for product differentiation. This evidence points to a life cycle in which successful exporters typically start small and grow progressively as they age; first at home, then abroad; while upgrading the quality of their products. We discuss the implications of these findings for recent theories of export dynamics.

*Keywords*: Firm-level exporting, firm dynamics, product quality.
*JEL*: F1.

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# 1 Introduction

A growing body of evidence reveals that exporting activity is characterized by a high degree of granularity: few firms export, and a small proportion of these sell many products in many destinations, generating the bulk of export revenue in each nation (Bernard et al. 2007; Mayer and Ottaviano, 2007). Large exporting firms help define specialization patterns and play a key role in shaping the impact of trade liberalization on macroeconomic volatility (Freund and Pierola, 2012; di Giovanni and Levchenko, 2012). But while there is renewed interest on links between trade, specialization and growth at the national level (Chenery, 1960; Leamer 1984; Hausmann et al, 2007; Trefler and Sutton, 2011), we still know relatively little about the dynamic process by which (some) firms become successful exporters (Verhoogen, 2012).

In this paper, we use customs and firm-level census data from the Portuguese manufacturing sector to study the evolution of export performance over the firm life cycle. Examining different cohorts in the cross-section of firms, we find that, as firms age, the distributions of employment, export revenue, number of destinations and exported products shift progressively to the right. To understand the dynamics underlying this cross-sectional heterogeneity, we identify entrants in a given year and track their behavior over time. We find that market selection based on initial size or export performance plays a minor role in explaining the observed heterogeneity in performance across cohorts: the main driver appears to be growth of surviving firms, not differences between the initial observable attributes of survivors and exitors. Why, then, only a minority of firms eventually grow and succeed in export markets? Returning to the cross-section of firms, we show that in the process of aging, firms progressively pay higher wages, import more expensive inputs, and charge higher prices for exports, especially in sectors with greater scope for quality differentiation. These patterns in the data are consistent with a life cycle in which more capable entrepreneurs typically start small and grow as they age; first at home, then abroad; while progressively using higher-quality inputs in order to upgrade the quality of outputs.

We contribute to the emerging literature on export dynamics at the firm-level. A strand of this literature offers dynamic extensions of Melitz (2003) in which firms experience idiosyncratic shocks to their productivity and/or demand, including Ruhl and Willis (2008), Arkolakis (2011) and Impullitti et al. (2013). A related class of models links export dynamics to learning about foreign markets and trade relationships (Albornoz et al., 2012; Chaney, 2011; Eaton et al., 2012). While the microfoundations of export dynamics vary considerably across models, this literature does a good job at rationalizing age-dependent growth in foreign markets, both within and across destinations. Existing theories are less well-suited, however, to explain the systematic increase in average wages, imported input prices and export prices over the life cycle we document. While the progressive increase in export prices among survivors could reflect larger markups due to learning about demand,

it seems difficult to account for the progressive increase in wages and imported input prices without appealing to progressive product quality upgrading.[1]

Our findings also contribute, therefore, to the literature on product quality and trade at the firm-level. Verhoogen (2008) offers an extension of the Melitz (2003) model in which the production of higher-quality outputs requires higher-quality inputs; more capable entrepreneurs endogenously choose to produce higher-quality goods; and firms optimally choose to upgrade the quality of their products in order to appeal to consumers in richer export markets.[2] Several recent pieces of evidence have consistently provided support to the central elements of this theory. Verhoogen (2008) shows that Mexican manufacturing plants facing greater incentives to serve the US recorded increases in average wages, the share of skilled labor, and ISO 9000 certification. In Portuguese data, Bastos and Silva (2010a) find that, within narrow product categories, higher-productivity firms tend to sell higher quantities at higher prices, consistent with higher product quality. In addition, they document that within-firm-product export prices rise systematically with distance and destination market income.[3] Using a rich plant-product data set for the Colombian manufacturing sector, Kugler and Verhoogen (2012) show that larger plants charge higher prices for outputs and pay higher prices for material inputs, consistent with higher product quality.[4] Brambilla et al. (2012) find that, when faced with greater incentives to serve the US and EU markets, Argentinian firms raised average wages and became more skill intensive. Using customs and firm-product panel data, and exploiting exchange rate movements to obtain plausibly exogenous variation in export destinations within firms, Bastos et al. (2011) find that an increase in the average income of export destinations leads Portuguese firms to charge higher prices for outputs and pay higher prices for material inputs, on average. In the context of this literature, our main contribution is to shed light on the dynamic interplay between product quality upgrading and firm performance in export markets over the firm life cycle.

[1] In addition to the articles cited above, our paper is related to a growing empirical literature using transactions-level data to study short-run dynamics of exporting activity at the firm-level, including Eaton et al. (2008), Cadot et al. (2011), Iacavone and Javorcik (2010) and Freund and Pierola (2010). Relative to this body of work, a key distinguishing feature of our paper is the ability to link trade transactions to comprehensive information on firm age and other attributes. Unlike transactions-level data alone, the data we use makes it possible to examine the evolution of firm size and export performance over the life cycle.

[2] Kugler and Verhoogen (2012) and Bastos et al. (2011) develop related theoretical frameworks in a general equilibrium context.

[3] These findings have proved to be quite robust across countries and data sets. More recent papers have documented similar patterns in trade-transactions data from China, France and Hungary (Manova and Zhang, 2012; Martin, 2012; Görg et al., 2010).

[4] More recent papers provide several additional pieces of evidence on the relationship between output prices, input prices and firm characteristics. Manova and Zhang (2012) show that Chinese firms that export more, serve more markets and charge higher prices for exports tend to pay more for their imported inputs. Examining data for manufacturing plants in India, the US, Chile, and Colombia, Hallak et al. (2013) document that, conditional on size, exporting firms charge higher prices, pay higher wages, use capital more intensively, and purchase more expensive material inputs.

Finally, our paper complements and extends the work of Cabral and Mata (2003), who use firm-level data from the Portuguese manufacturing sector to examine the evolution of the firm size distribution (FSD). They show that FSD is significantly right-skewed and evolves over time toward a lognormal distribution. They also find that this evolution is largely driven by the growth of survivors (as opposed to selection based on initial size), and propose an explanation based on age-dependent financial constraints.[5] In a key departure from their work, we examine the evolution of export performance over the life cycle and provide evidence that product quality upgrading appears to go hand-in-hand with firm growth in export markets.

The remainder of the paper proceeds as follows. Section 2 describes the data employed. Section 3 presents stylized facts on the distribution of firm size and export performance across the various cohorts of firms. Section 4 uses longitudinal data to examine the relative importance of selection versus firm growth in driving the observed performance heterogeneity across cohorts. Section 5 examines relationships between firm age, export prices and input prices with a view to make inferences about the evolution of product quality over the firm life cycle. In Section 6 we discuss the implications of our findings for recent theories of export dynamics. The last section concludes.

# 2 Description of data sets

## 2.1 Data sources

We link and examine data from the *Foreign Trade Statistics* (FTS) and the *Enterprise Integrated Accounts System* (EIAS) of Portugal for the years 2005 and 2009.

The FTS are the country's official information source on international trade statistics, gathering export and import transactions of firms located in Portugal by product and destination market. These data are collected in two different ways. Data on trade with countries outside the EU (external trade) are collected via the customs clearance system, which covers the universe of external trade transactions. Information on the transactions with other EU member States (internal trade) are obtained via the Intrastat system, where the information providers are companies engaged in internal trade and registered in the VAT system whose value of annual shipments exceeds a legally binding threshold. Export and import values in these data are "free on board", hence excluding any duties or shipping charges. Despite the above-mentioned constraint, the export and import transactions included in the FTS data aggregate to nearly the total value of merchandise exports and imports reported in the official national accounts.

The EIAS is a census of firms operating in Portugal run by the National Statistics

[5] Drawing on survey-based measures of financial constraints, Angelini and Generale (2008) show that the FSD of non-financially constrained firms is almost always visually and statistically indistinguishable from that of the entire sample. They conclude that financial constrains cannot be the main driver of the evolution of firm size over life cycle, especially in financially developed economies.

Institute. Among other variables, it contains information on total employment, date of constitution, capital stock, value added, industry code, location and foreign ownership status. The latter variable is an indicator taking the value of 1 if the control of the firm is located in a country other than Portugal and 0 otherwise.

We have linked the FTS and EIAS data sets using unique firm identifiers.[6] As is customary in the empirical trade literature, we restrict the analysis to firms whose main activity is in the manufacturing sector excluding the Petroleum sector. We impose these restrictions using the firm's self-reported industry code in the EIAS data set, where sectors are defined by the Revision 2.1 of the National Classification of Economic Activities (CAE).[7]

## 2.2 Summary statistics

Table 1 reports summary statistics on manufacturing firms operating in Portugal, according to their export and foreign ownership status in 2005.

Table 1: Firm attributes by export and ownership status

| | all firms | exporters | | | non-exporters | | |
|---|---|---|---|---|---|---|---|
| | | all | domestic | foreign | all | domestic | foreign |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Employment | 17.2 | 62.7 | 51.5 | 203.6 | 9.0 | 8.9 | 28.1 |
| | (61.3) | (143.3) | (97.8) | (370.0) | (16.2) | (15.8) | (53.1) |
| Age | 14.5 | 21.1 | 21.0 | 23.4 | 13.3 | 13.3 | 13.7 |
| | (13.3) | (15.7) | (15.5) | (17.3) | (12.5) | (12.5) | (11.9) |
| Avg. earnings | 8.2 | 11.3 | 10.2 | 24.9 | 7.6 | 7.6 | 20.7 |
| | (32.6) | (55.9) | (6.0) | (204.3) | (25.5) | (25.5) | (16.1) |
| K/L | 69.0 | 99.0 | 92.1 | 186.5 | 63.1 | 62.3 | 268.9 |
| | (1009.6) | (268.0) | (191.1) | (715.9) | (1099.1) | (1100.8) | (426.3) |
| VA/L | 17.0 | 23.5 | 20.6 | 59.3 | 15.7 | 15.6 | 55.8 |
| | (351.0) | (125.1) | (21.8) | (452.7) | (380.3) | (380.9) | (121.2) |
| % firms | 100 | 15.4 | 14.3 | 1.1 | 84.6 | 84.2 | 0.4 |

Notes: Summary statistics refer to the 44,853 manufacturing firms that are present in the 2005 EIAS. Standard deviations in parentheses. Earnings are annual, measured in thousands of 2005 euros. Exporter defined as export sales $> 0$ in the FTS. Foreign-owned defined as country of final control other than Portugal. K/L and VA/L are, respectively, measures of physical capital stock per worker and value added per worker in thousands of 2005 euros.

[6] In both the FTS and EIAS, firms are uniquely identified by their tax identification number (NPC). Hence the mapping of the two data sets was straightforward. After merging the two data sets, the Statistics Institute applied a transformation of the NPC to the data that were made available to researchers in order to preserve confidentiality.

[7] Firms reporting their main activity to be in the manufacturing sector account for about 86.3% of total exports in the FTS data set for 2005. Firms in the Petroleum sector (CAE 23) account for 4.6% of total export revenue recorded in the customs data set.

The information reported in this table reveals that the vast majority of firms operating in Portugal are domestically-owned (98.5% of the total). In line with existing evidence for many other countries (see, e.g., Bernard et al., 2007), we also see that firm size is systematically associated with export and foreign ownership status: exporters tend to be larger than non-exporters; foreign firms are on average much larger than domestically-owned firms.

Table 2: Export revenue, destinations and products

| | all exporters | domestic exporters | foreign exporters |
|---|---|---|---|
| | (1) | (2) | (3) |
| Export revenue | 3179.4 | 1918.2 | 19008.7 |
| | (25594.6) | (11354.6) | (3179.4) |
| # products | 7.7 | 7.18 | 14.3 |
| | (13.9) | (13.0) | (21.07) |
| # destinations | 5.2 | 4.9 | 9.2 |
| | (7.4) | (7.0) | (10.9) |

Note: Data refer to manufacturing firms that report non-zero export revenue in the FTS data. Standard deviations in parentheses. Export revenue is measured in thousands of 2005 euros. Number of products or destinations refers to number of distinct categories or distinct export destinations in which non-zero export revenues are reported.

Table 2 reports additional summary statistics, now focusing solely on exporters. The average exporting firm in 2005 obtained 3.18 million euros of export proceeds. When cutting the data by foreign ownership status, we see that foreign firms export almost 10 times more than domestically-owned firms: 1.92 million versus 19.0 million euros of export revenue on average, respectively. The large differences in average export proceeds are also reflected in sizable heterogeneity in the number of destinations served and products exported.

Figure 1 depicts the distributions of log firm employment and the three measures of export performance presented above. As in Cabral and Mata (2003) and Angelini and Generale (2008) we draw on nonparametric estimation methods, notably a kernel density smoother. These methods offer a convenient way of estimating the density of the distribution without imposing much structure on the data.[8] The upper-left panel of this figure shows that the FSD of domestic firms is skewed to the right and has a relatively long tail. This shape is quite similar to that reported by Cabral and Mata (2003) for the universe of Portuguese manufacturing firms in 1991. This panel further confirms the well-known result that foreign firms tend to be larger than their domestic counterparts; see, e.g., Doms and Jensen (1998) for the US, Kimura and Kiyota (2007) for Japan, or Mata and Portugal (2002, 2004) for Portugal. Figure 1 further suggests that the firm size distribution of foreign firms is log-normal.[9]

[8] As in Angelini and Generale (2008) we use a bandwidth of 0.7. Estimation with alternative bandwidths or kernels leads to qualitatively similar results.

[9] To corroborate the visual evidence we performed a non-parametric Kolmogorov-Smirnov test. For domestically-owned firms, the null hypothesis is clearly rejected, with a corrected combined K-S p-value

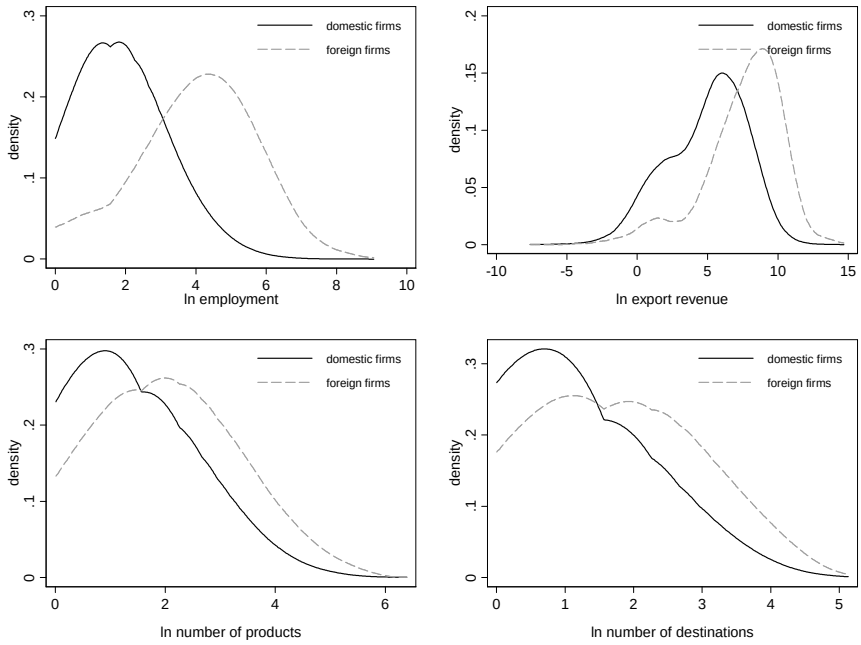


Figure 1: Size and export performance distributions

With regard to export revenue, we see that the distributions are highly skewed to the right. We also see that distribution of export revenue of foreign-owned firms presents a similar shape but is clearly shifted to the right, consistent with their larger size and superior export performance reported in Tables 1 and 2. Regarding the number of products and destinations, it is clear that most domestically-owned firms export a very small number of products and/or serve a small number of destinations. Yet there exists a fairly small number of these firms exporting many products and/or serving many markets. Once again, the distributions for foreign firms are shifted to the right, pointing to a superior export performance also along these dimensions. Overall, this evidence is in line with the stylized fact that a small number of large exporters tend to export more products and serve more markets, accounting for the bulk of export revenue in each nation (Bernard et al., 2007; Mayer and Ottaviano, 2007; Freund and Pierola, 2012).

## 3 Export performance across cohorts

We now turn to the evolution of export performance over the firm life cycle. We begin by comparing the distribution of export performance across age-cohorts in 2005. Since firm age is not a well-defined concept among subsidiaries of multinational firms, we restrict the

of 0.00. By contrast, for foreign firms the null of the hypothesis that the distribution of firm size is log normal cannot be rejected, with a corrected combined K-S p-value of 0.36.

attention to domestically-owned firms.[10]

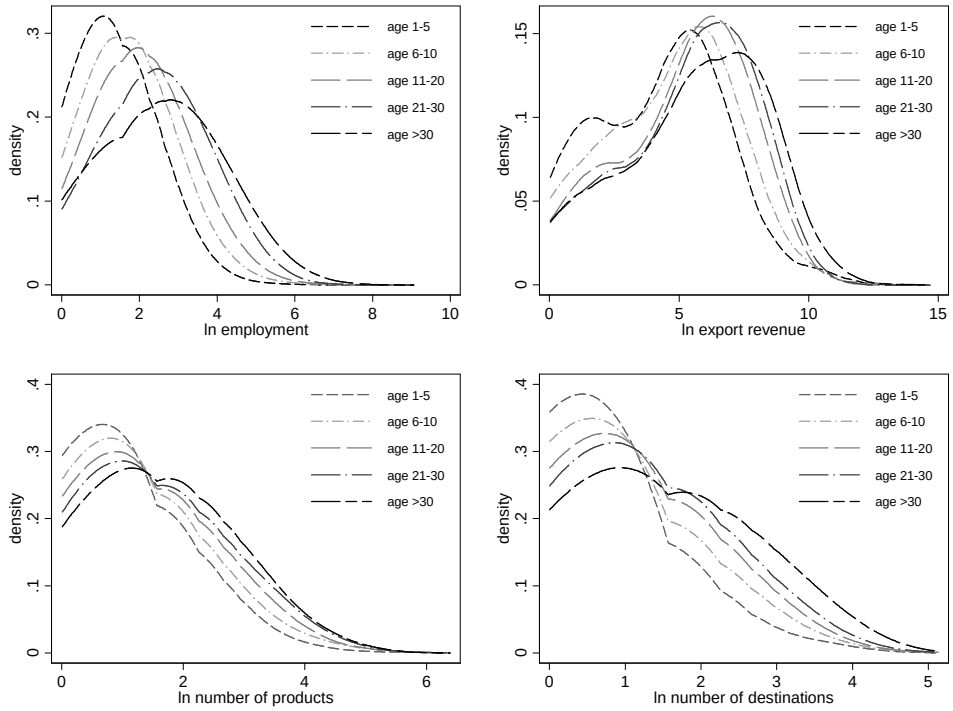


Figure 2: Size and export performance across cohorts (domestically-owned firms)

The top left panel of Figure 2 depicts the evolution of the firm size distribution of various cohorts. The results are well in line with those reported by Cabral and Mata (2003): as firms age, the size distribution shifts progressively to the right. The diagrams reported in the remainder of this figure focus solely on exporting firms, and show the distribution of export performance measures by age. The right-upper panel of Figure 2 shows the distribution of export revenue by age. Similarly to what happens with size, we see that, as exporting firms age, the distribution of export revenue shifts systematically to the right. In the bottom panels of this figure, we show how the distributions of the number of products and destinations evolve with age. Once again, we see that, as firms age, these distributions shift progressively to the right.

[10]The date of constitution of foreign-owned firms typically corresponds to the moment in which the affiliate firm started operating in Portugal. A firms' capital may also have been aquired by foreign investors, while preserving the initial date of constitution. In either case, the parent multinational firm may be a mature firm that can transfer assets, inputs and knowledge to the affiliate. Foreign firms in Portugal are also more likely to reflect export-platform FDI directed to other European countries. The dynamic process underlying the evolution of their size and export performance over the life cycle might therefore be expected to differ from that of domestically-owned firms. Appendix B provides evidence on this evolution for foreign-owned firms.

The visual inspection of Figure 2 points to a clear relationship between firm performance and age. A potential concern about this evidence is that firms are heterogeneous with regard to industrial activity and location, which might be systematically related with age and performance. We examine this issue further by estimating an equation of the form:

$$\ln y_i = \beta age_i + \lambda_k + \tau_r + \varepsilon_i \tag{1}$$

Where $y_i$ is a measure of size or export performance of firm $i$, $age_i$ is the number of years passed since birth, $\lambda_k$ is an industry fixed-effect, $\tau_r$ is a region fixed-effect, and $\varepsilon_i$ a random term. Table 3 reports the corresponding results.

Table 3: Semi-elasticity between performance and age

| dep. variable: | all firms | exporters | | | |
|---|---|---|---|---|---|
| | employment | employment | export revenue | # products | # destinations |
| | (1) | (2) | (3) | (4) | (5) |
| Age | 0.031*** | 0.032*** | 0.030*** | 0.012*** | 0.014*** |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) |
| Industry effects | Y | Y | Y | Y | Y |
| Region effects | Y | Y | Y | Y | Y |
| N (obs./distinct firms) | 43871 | 6386 | 6386 | 6386 | 6386 |

Notes: Robust standard errors in parentheses. *10% level, **5% level; ***1% level. Sample restricted to domestically-owned firms.

The point estimates corroborate very clearly the visual findings. From Table 3 we see that one additional year of age is associated with a rise in employment of 3.1%, on average. Among exporters, one additional year is associated with an increase in employment by 3.2%, export revenue by 3%, the number of products exported by 1.2% and the number of destinations served by 1.4%.[11]

# 4 Selection versus growth

In the analysis above, we have characterized the evolution of export performance over the life cycle using information on the cross-section of firms for 2005. A potential explanation for the observed heterogeneity in size and export performance across cohorts is selection. If firms that are inititally larger and have better export performance are more likely to survive, mature firms will naturally be larger and have stronger export performance even in the absence of systematic growth patterns over the life cycle. Following Cabral and Mata (2003) we evaluate the empirical relevance of this mechanism by identifying the universe of entrants in 2005 and tracking their performance until 2009. From the 1723

[11] In results not reported (but available upon request) we find that these point estimates remain very similar when industry and/or region fixed-effects are excluded.

domestically-owned manufacturing firms that entered the market in 2005, 1183 were still operating in 2009. Figure 3 depicts the FSD of these two sets of firms in 2005, as well the 2009 FSD of survivors. We see that the FSD of survivors in 2009 is clearly less skewed to the right than that of the universe of entrants in 2005. If selection based on initial size (exit of initially smaller firms) were to explain this evolution, the FSD of survivors would be expected to be fairly similar in 2005 and 2009. By contrast, if differential growth of initially similar firms were to explain this evolution, the initial FSD of survivors would be expected to resemble that of the universe of entrants in 2005. An inspection of Figure 3 shows that firm growth, as opposed to selection based on initial size, is the main driver of the evolution of performance over the life cycle.

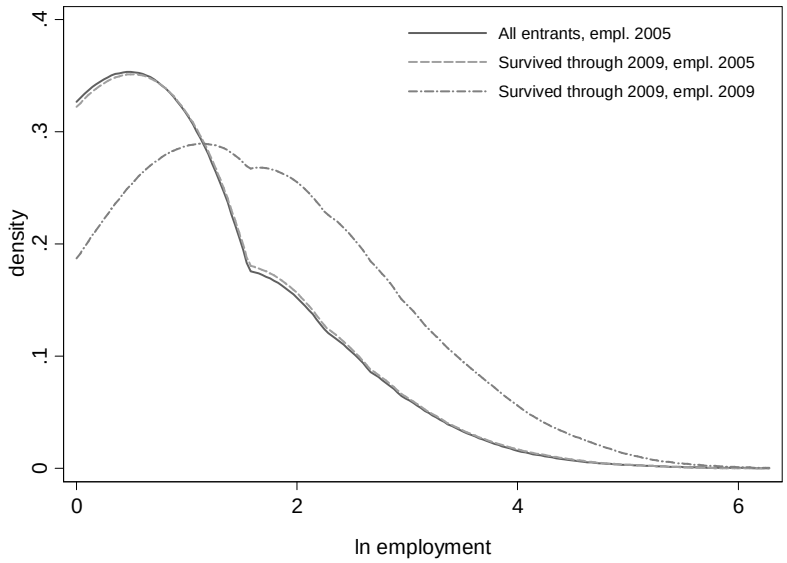


Figure 3: Size distribution of the 2005 cohort of entrants

In Table 4 we conduct an analogous exercise, but now focusing on the evolution of export performance indicators. We see that, in the year of birth, the export performance of the 2005 cohort of entrants is fairly similar to that of the sub-group of firms that survived until 2009. In all four indicators of export performance considered, surviving firms exhibit stronger performance than the average entrant. But these differences are not large. When we compare the performance of the group of firms that survived until 2009 we observe much larger performance differentials than the initial heterogeneity between survivors and all entrants: in 2005 only 2.5% of survivors were exporters; in 2009 this percentage had more than tripled to 8.7%. In terms of average export revenue, we see that average exports (including exporters and non exporters) increased by a factor of 5 from 17.2 thousand euros to 93.22 thousand euros in real terms. Regarding the number of products and export destinations, we see that the former increased by a factor of 5 while

the latter expanded by a factor of 4. Overall these results suggest that market selection based on initial export performance accounts for very little of the observed heterogeneity of export performance across cohorts. Growth of survivors over the life cycle (from a fairly similar observable starting point) is clearly the main driver of this heterogeneity.

Table 4: Size and export performance of the 2005 cohort of entrants

| | all entrants | entrants that survived through 2009 | |
|---|---|---|---|
| | 2005 | 2005 | 2009 |
| Employment | 4.03 | 4.00 | 8.89 |
| | (9.93) | (7.66) | (15.31) |
| Exporter | 0.023 | 0.025 | 0.087 |
| | (0.151) | (0.157) | (0.282) |
| Export revenue | 12.51 | 17.17 | 93.22 |
| | (341.37) | (411.54) | (1122.27) |
| # products | 0.09 | 0.10 | 0.51 |
| | (1.02) | (1.10) | (2.66) |
| # destinations | 0.07 | 0.08 | 0.32 |
| | (0.81) | (0.96) | (1.88) |
| N (obs./distinct firms) | 1723 | 1183 | 1183 |

Notes: Standard deviations in parentheses. Exporter defined as export sales $> 0$ in the FTS. Export revenue measured in thousands of 2005 euros. Number of products or destinations refers to number of distinct categories or distinct export destinations in which non-zero export revenues are reported. Sample restricted to domestically-owned firms.

# 5 Wages, import prices and export prices across cohorts

Having shown that selection based on initial size or export revenue accounts for a minor part of the evolution of export performance over the life cycle, we proceed by examining heterogeneity of output and input prices across cohorts of firms. As discussed in more detail below, several models of firm dynamics (with or without international trade) assume that firm productivity rises over time, leading to firm growth through increased price competitiveness (e.g., Arkolakis, 2011). At the same time, evidence is mounting that the ability to produce higher product quality (as inferred from patterns of prices and quantities of both outputs and inputs) is an important driver of export performance across nations and firms (Hummels and Klenow, 2005; Bastos and Silva, 2010a; Kugler and Verhoogen, 2012; Bastos et al. 2011). If firm growth over the life cycle reflects mainly increased productivity, we would expect to observe a negative relationship between export prices and age. By contrast, if firm growth is mainly rooted in product quality upgrading, and if production of higher-quality goods requires using more expensive inputs, we would expect to observe higher output and input prices among older firms, especially in product categories with larger scope for vertical differentiation.

In order to gain insight about the mechanisms behind the growth of exporting firms over the life cycle, we run simple regressions of the form:

$$\ln p_{iklj} = \beta age_i + \psi_j + \theta_k + \eta_l + \varepsilon_{ijkl} \tag{2}$$

where $p_{ijk}$ is the import price paid (export price charged) by firm $i$, operating in industry $k$ and located in region $l$, for product-source (product-destination) pair $j$. We also run simple regressions with average earnings at the firm-level, where subscript $j$ is not relevant. The terms $\psi_j$, $\theta_k$ and $\eta_l$ are product-destination (product-source) pair, industry and region fixed-effects, respectively.

To further inspect for evidence of product quality upgrading over the life cycle, we allow the price-age relationship to vary across product categories of the Rauch (1999) product classification scheme. This classification divides SITC 4-digit product categories into three groups: homogeneous, reference price, and differentiated products. The first group comprises commodities that are traded in organized exchanges (e.g. steel, tea, or tobacco); the second includes groups that are not sold on organized exchanges but have a benchmark price (e.g. chemicals with reference prices listed in industry guides); the remaining product categories are classified as differentiated.[12] Using Portuguese transactions data for 2005, Bastos and Silva (2010b) show that export prices within differentiated products are significantly more heterogeneous than they are within reference price and homogeneous goods, suggesting that Rauch's categorization scheme is well-suited for identifying differentiated products in empirical applications. Building on this work, we verify if and how the price-age relationship varies systematically with the scope for quality differentiation by estimating an equation of the form:

$$\ln p_{iklj} = \beta_1 age * D_i + \beta_2 age * RP_i + \beta_3 age * H_i + \psi_j + \theta_k + \eta_l + \varepsilon_{ijkl} \tag{3}$$

where $D_i$, $RP_i$ and $H_i$ are indicator variables for differentiated, reference price and homogeneous products, respectively.

Table 5 reports the point estimates from (2). We see that average worker earnings and export prices increase systematically with age.[13] For imported input prices, the estimated coeffiecient on age is also positive, but statistically insignificant at conventional levels, with a p-value of 0.14 in column (3) and 0.11 in column (5). As mentioned above, a possible explanation for the observed rise in export prices with age is greater ability of older firms to obtain larger markups, for instance because of higher productivity, reputation, or market power. An alternative explanation, which is not necessarily mutually exclusive, is that higher export prices among older firms reflect product quality upgrading. The progressive rise of average worker earnings with age is consistent with a product quality explanation.

[12] We linked the firm-product data with Rauch's (1999) classification using a concordance between the CN and SITC classifications made available online by RAMON, the Eurostat's metadata server.

[13] In columns (1) and (2), the loss in the number of observations relative to Table 3 is due to the fact that the variable average earnings uses information on the number of salaried employees (as opposed to the total number of employees). In some small businesses, the owners are the sole employees of the firm and do not receive a salary.

But it is also consistent with other mechanisms, such as rent-sharing or a progressively more efficient workforce. A rise in imported input prices with age is more difficult to explain in the absence of product quality upgrading. But the coefficient of interest is statistically insignificant in the full sample of products.

Table 5: Semi-elasticity between wages, import prices, export prices and age

| | all firms | exporters | | | importers |
|---|---|---|---|---|---|
| Dep. variable | avg. earnings | avg. earnings | imp. prices | exp. prices | imp. prices |
| | (1) | (2) | (3) | (4) | (5) |
| Age | 0.008*** | 0.004*** | 0.0009 | 0.002*** | 0.0009 |
| | (0.000) | (0.000) | (0.0006) | (0.001) | (0.0006) |
| Source/dest-prod effects | N | N | Y | Y | Y |
| Industry effects | Y | Y | Y | Y | Y |
| Region effects | Y | Y | Y | Y | Y |
| N (obs.) | 40,246 | 6,320 | 68,902 | 87,597 | 86,723 |

Notes: The number of observations in columns (1)-(2) measure the number of distinct firms; in columns (3)-(5) they refer to number of firm-product-destination cells. Robust standard errors in parentheses, clustered by firm in columns (3)-(5). *10% level, **5% level; ***1% level. Sample restricted to domestically-owned firms.

To discriminate further between these hypotheses, we examine the heterogeneity of the price-age coefficients across product groups of the Rauch classification. In our data, there is a greater prevalence of homogeneous and reference price products for imported inputs than for exported products. Among the former, homogeneous and reference price products account, respectively, for 6% and 22% of firm-product-source observations, whereas among the latter they account for 2% and 14% of firm-product-destination observations.

The point estimates reported in Table 6 lend support to the quality upgrading interpretation. Among differentiated products, we observe a positive and significant price-age relationship, both for exports and imported inputs. By contrast, for products that are classified as non-differentiated (either reference price or homogeneous) the price-age relationship is insignificant.[14] Together with our earlier findings, this evidence is strongly suggestive that product quality upgrading is systematically associated with firm growth over the life cycle.

[14]The results shown are based on the "liberal" version of the Rauch (1999) classification, but similar results were obtained using the "conservative" classification (not reported but available upon request).

Table 6: Cross-product heterogeneity in price-age relationships

| | exporters | | importers |
|---|---|---|---|
| Dep. variable | imp. prices | exp. prices | imp. prices |
| | (1) | (2) | (3) |
| Age × differentiated | 0.002** | 0.003*** | 0.002** |
| | (0.001) | (0.001) | (0.001) |
| Age × reference price | −0.001 | −0.001 | −0.001 |
| | (0.001) | (0.001) | (0.001) |
| Age × homogeneous | −0.001 | -0.002 | -0.0002 |
| | (0.001) | (0.003) | (0.0009) |
| Source/destination-product effects | Y | Y | Y |
| Industry effects | Y | Y | Y |
| Region effects | Y | Y | Y |
| N (obs./firm-product-destination) | 68,388 | 87,597 | 86,723 |

Notes: Robust standard errors in parentheses, clustered by firm. *10% level, **5% level; ***1% level. Sample restricted to domestically-owned firms.

# 6 Models of export dynamics in the literature

In this section we critically review recent models of export dynamics in the light of the stylized facts documented above. Our aim is to evaluate the extent to which the different mechanisms proposed in the literature are capable of accommodating the facts, and help identifying new avenues for theoretical research. As discussed above, the evidence we provide clearly points to progressive, age-dependent growth over the firm life cycle, both at home and abroad. In Table 7, we summarize some of the central features of recent theories of export dynamics that can account for age-dependent growth in export markets.

A strand of theoretical work develops dynamic extensions of Melitz (2003) in which firms experience idiosyncratic shocks to their productivity and/or demand. In a calibration exercise based on Colombian data, Ruhl and Willis (2008) find that a standard heterogeneous firm model with productivity shocks alone cannot replicate the behavior of new exporters. These authors also show that allowing for (ad-hoc) demand shifters that grow over time makes it possible to rationalize the slow growth of exporters as they enter new markets. In Arkolakis (2011), firms enter a market when it is profitable to incur the marginal cost to reach the first consumer and pay an increasing marketing cost to reach additional consumers. While the model is not primarily designed to generate age-dependent growth, such growth arises as a consequence of firm selection together with the stochastic evolution of firm productivities. Lucky firms receive a series of positive productivity shocks over a number of years. Unlucky firms do not grow as much or contract. Hence they operate close to the productivity cutoff and are more likely to get selected out as time goes by if hit by negative shocks. Impullitti et al. (2013) develop a related dynamic model featuring idiosyncratic firm shocks to firm efficiency. The presence of sunk

export entry costs and productivity uncertainty leads to to hysteresis in export market participation. A firm enters the export market once it achieves a given size, reflecting its efficiency, but may keep exporting even after its efficiency has fallen below its initial entry level. Some exporters will not be selling as much in the domestic market as other firms that never entered the foreign market.

A related class of models links export dynamics at the firm-level to learning about foreign markets and trade relationships. Albornoz et al. (2012) develop a simple dynamic model based on experimentation in export markets. Individual export profitability is initially uncertain, but positively correlated over time and across destinations. This induces "sequential exporting" where the possibility of profitable expansion at the intensive and extensive margins makes initial entry costs worthwhile despite high failure rates. Morales et al. (2011) use a moment inequalities approach to estimate a related model of sequential export choice across destinations. In the model, profits from each possible destination market depend on: (1) how similar it is to the firm's home country (gravity); and (2) how similar it is to other destinations to which the firm has previously exported (extended gravity). In Eaton et al. (2012), heterogeneous sellers search for buyers in a single export market. Firms differ in efficiency and product appeal, and success in selling to a buyer reveals information about the appeal of the seller's product in the market, affecting the incentive to search for more buyers. They also learn about appeal of their product from their experiences in their home markets. Timoshenko (2012) develops a related multi-product model of demand learning in which an exporter's profitability on the demand side is determined by a time-invariant firm-destination appeal index, and transient firm-destination-year preference shocks. New exporters must learn about their appeal indices in the presence of these shocks, and respond to fluctuations in demand by adding and dropping products more frequently than older exporters because they have less information about their attractiveness to consumers. Chaney (2011) models the growth of exporters as they meet importers through an evolving international network of contacts. Producers can only serve markets in which they have a contact. They directly search for new trading partners, but they can also use their existing network of contacts to remotely search for new partners. The ability of using existing contacts to find new ones is a distinctive asset of firms with many contacts, generating a fat tailed distribution of the number of contacts across firms. Firms differ with regard to the initial size and location of the consumer base, and follow a history dependent path when expanding into foreign markets.

Table 7: Type and causes of firm dynamics in export markets

| Relevant papers | Nature of firm heterogeneity | Product mix | Key mechanisms driving age-dependent growth in export markets |
|---|---|---|---|
| Albornoz et al. (2012) | Export profitability | Unspecified | Learning about potential in export markets; sequential market entry |
| Arkolakis (2011) | Efficiency | Differentiated product; constant over time | Random productivity shocks; marketing penetration costs; selection |
| Chaney (2011) | Size and location of initial consumer base | Differentiated product; constant over time | Direct and remote search; network of importers and exporters embedded into geography |
| Eaton et al. (2012) | Efficiency; product appeal | Differentiated product; constant over time | Search and learning about product appeal within single destination |
| Impullitti et al. (2013) | Efficiency | Differentiated product; constant over time | Random productivity shocks; sunk export entry costs |
| Morales et al. (2011) | Efficiency | Differentiated product; constant over time | Sequential export choice; exporting to a destination makes it easier to serve other similar markets (extended gravity) |
| Ruhl and Willis (2008) | Efficiency and foreign demand | Differentiated product; constant over time | Idiosyncratic productivity shocks; foreign demand increasing with export experience |
| Timoshenko (2012) | Efficiency; brand appeal; firm-destination demand shocks | Multiple product varieties; product scope evolves over time | Learning about demand and product switching |

While the specific mechanisms governing export dynamics vary considerably across models, when taken together they do a good job at rationalizing age-dependent growth in export markets, both within and across destinations. Existing models are less suited, however, to explain the systematic increase of average wages, import prices and export prices over the life cycle we document. While the progressive rise in export prices among survivors could reflect larger markups due to learning about demand, it seems difficult to explain the progressive increase in wages and imported input prices without appealing to progressive product quality upgrading, possibly linked to heterogeneity in innovation capabilities across producers. Recent theories of product quality and trade at the firm-level do allow for complementarity between firm capability and input quality in generating output quality, including Verhoogen (2008), Kugler and Verhoogen (2012), Bastos et al. (2011). But the static nature of these models makes them less suitable for examining endogenous innovation and export dynamics over the firm life cycle. Extending this class of models in this direction appears therefore to be a particularly promising area for future research.[15]

# 7 Conclusion

We have used a rich combination of transactions-trade and firm-level census data for Portuguese manufacturing to provide evidence on the evolution of export performance over the firm life cycle. We have shown that, as firms age, the distributions of employment, export revenue, number of destinations and exported products shift progressively to the right. We have also shown that this evolution does not appear to be driven by selection based on initial size or export performance; and that, in the process of aging, firms in sectors with greater scope for quality differentiation progressively pay higher wages, import more expensive inputs, and charge higher prices for exports.

The stylized facts we have documented are consistent with a life cycle in which successful exporters tend to start small and grow as they age; first at home, then abroad; while progressively using higher-quality inputs to upgrade the quality of their outputs. We have argued that, in order to match these patterns in the data, models of export dynamics should incorporate endogenous product innovation over the firm life cycle. Such a body of research may offer a stronger basis for designing policies capable of promoting industrial

[15] Klepper (1996) and Klette and Kortum (2004) develop influential models of firm dynamics and product innovation, but do not focus on international trade issues and do not model explicitly the interplay between firm capability and input quality in generating output quality. Atkeson and Burstein (2010) develop a model of firm dynamics featuring trade and product innovation, but place the focus on the offsetting responses of exit, export, innovation, and entry decisions to permanent trade liberalizations, as well as on the offsetting impacts of changes in these decisions on aggregate productivity and welfare. In a related setting, Burstein and Melitz (forthcoming) examine the effects of changes in these decisions on transition dynamics and average productivity, trade flows, and output, allowing for sunk export costs, considering both temporary and anticipated trade liberalizations.

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