Breaking down the barriers to firm growth in Europe:

The fourth EFIGE policy report

BY LORIS RUBINI, KLAUS DESMET, FACUNDO PIGUILLEM
AND ARÁNZAZU CRESPO

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Loris Rubini, Klaus Desmet, Facundo Piguillem and Aránzazu Crespo

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EFIGE is a project designed to help identify the internal policies needed to improve Europe's external competitiveness.

EUROPEAN COMMISSION

SEVENTH FRAMEWORK PROGRAMME

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EFIGE PARTNERS

The leaders of the eight teams are: Gianmarco I.P. Ottaviano, Bocconi University, for Bruegel; Lionel Fontagné, PSE, University of Paris I, for CEPII; Karen Helene Ullveit-Moe, University of Oslo, for CEPR; László Halpern for the Hungarian Academy of Sciences; Giorgio Barba Navaretti, University of Milan, for Ld'A; Claudia Buch, University of Tübingen, for IAW; Andrea Brasili for UniCredit; Klaus Desmet for Universidad Carlos III Madrid. Giorgio Barba Navaretti, Gianmarco I.P. Ottaviano and Thierry Mayer (PSE, CEPII and CEPR) coordinate the teams. Delphine Michel, Bruegel, is the project manager.

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Foreword

This report is the sixth and last in a series devoted to the firm-level determinants of export and economic performance. The series started in 2007 with the *Happy Few* report. It is based on the EFIGE survey of European firms organised by a Bruegel-led team of European researchers from seven centres, with the support of the European Commission and the UniCredit Group. Five years and countless pages later, it is time to draw lessons from this ambitious research.

EFIGE REPORTS PUBLISHED BY BRUEGEL

- *The Happy Few: the internationalisation of European firms*, by Thierry Mayer and Gianmarco Ottaviano, 2007 (this report pre-dated the EFIGE survey and provided the intellectual impetus for the project).
- *Of markets, products and prices: the effects of the euro on European firms*, by Lionel Fontagné, Thierry Mayer and Gianmarco Ottaviano, 2009
- *The global operations of European firms*, by Daniel Horgos, Daniela Maggioni, Fabiano Schivardi, Giorgio Barba Navaretti, Matteo Bugamelli and Carlo Altomonte, 2011
- *Still standing: how European firms weathered the crisis*, by Gábor Békés, László Halpern, Miklós Koren and Balázs Muraközy, 2011
- *The triggers of competitiveness: the EFIGE cross-country report*, by Carlo Altomonte, Tommaso Aquilante and Gianmarco Ottaviano, 2012
- *Breaking down the barriers to firm growth in Europe*, by Aránzazu Crespo, Klaus Desmet, Facundo Piguillem and Loris Rubini, 2012

The first lesson is a methodological one: whereas ten years ago economists and policymakers routinely discussed competitiveness on the basis of aggregate trade and investment flows, it has become unimaginable to overlook the firm-level dimension of international economic performance. As Richard Baldwin and I wrote in the foreword of *The Happy Few*, nations do not trade, it is firms that trade. This simple truth has become obvious and to speak of competitiveness without speaking of firms is now as awkward as to speak of employment without speaking of job destruction and creation. We are proud to have contributed to this intellectual and policy revolution.

Second, there is a strong and robust correlation between firm internationalisation and firm performance. Simply put, and as documented again in this report, a firm that exports tends to be also more profitable, more productive and more innovative. Again this may seem evident – but if it were to everyone, would globalisation be so disputed?

Third, the evidence collected within the framework of the project has confirmed to a remarkable extent that in different countries, firms with the same characteristics tend to behave in the same way with respect to international competition. German entrepreneurs may have a stronger propensity to export and invest abroad, but this is not what explains Germany's strong presence on international markets. Rather, it is the density of medium-sized, skill-endowed and innovative firms that explains German export performance. In this respect this report brings new evidence to the fore, showing that in comparison, the less stellar trade performances of Italy and Spain are due to the much higher density of small firms.

Fourth and consistent with the previous findings, to let domestic firms grow is one of the surest ways to improve export performance. But as demonstrated by this report, how to tear down barriers to growth is a country-specific question. Obstacles can be of different natures – they can originate in product, labour, technology and financial markets – and the binding constraints may be different from one country to another. So there is no one-size-fits-all recipe for firm growth and exports, rather each government must do its homework and identify domestic roadblocks.

Fifth, the relationship between firm characteristics and internationalisation is highly non-linear. Exports and FDI involve fixed costs and this gives rise to threshold effects. For this reason, long-distance exports and, to an even greater extent, FDI rely on a tiny group of truly global firms. In comparison to those serving the domestic market, only a minority of firms are serving even the closest neighbouring market. From a policy perspective, this implies that the highest returns from public action are to be expected from initiatives that 'fatten the tail' of globally competitive firms. If this can be done without picking the winner is a question of major relevance for all governments looking for ways to improving competitiveness.

We at Bruegel are convinced that this research has profound policy implications, especially in the current context of adjustment and rebalancing within the euro area. We recognise, however, that the European policy conversation has not yet drawn the full conclusions from it, and we acknowledge that researchers themselves have yet to contribute more convincingly to its upgrading. How countries in southern Europe that need to reallocate labour and capital massively to the traded-goods sector and improve their export-to-GDP ratio can do so without suffering a major deterioration in their terms of trade is, for example, a question we would wish to be able to provide more specific guidance on.

So there is room for research, as the saying goes. The EFIGE research results have already been considered important enough for the European Central Bank to launch a research initiative – the Competitiveness Network (CompNet) – that will build on them. We hope that this will lead to further insights on competitiveness and the ways to improve it.

The existing harvest, however, is rich enough already to provide to policymakers food for thought and fuel for action.

Jean Pisani-Ferry, Director, Bruegel
Brussels, August 2012

Executive summary

Large firms contribute disproportionately to the economic performance of countries: they are more productive, pay higher wages, enjoy higher profits and are more successful in international markets. The differences between European countries in terms of the size of their firms are stark. Firms in Italy and Spain, for example, are on average 40 percent smaller than firms in Germany. The low average firm size translates into a chronic lack of large firms. In Italy and Spain, a mere 5 percent of manufacturing firms have more than 250 employees, compared to a much higher 11 percent in Germany. Understanding the roots of these differences is key to improving the economic performance of Europe's lagging economies.

So why is there so much variation in firm size in different European countries? What are the barriers that keep firms in some countries from growing? And which policies are likely to be most effective in breaking down those barriers? This policy report aims to answer these questions by developing a quantitative model of the seven European countries covered by the EFIGE survey (Austria, France, Germany, Hungary, Italy, Spain and the UK). The EFIGE survey asked 14,444 firms in those countries about their performance, their modes of internationalisation, their staffing decisions, their financing structure, and their competitive environment, among other topics[1].

The fact that larger firms export more and innovate more suggests that barriers to research and development and to trade are the main culprits that slow down firm growth. Countries that face higher trade costs provide fewer opportunities for businesses to become large. And a relative absence of R&D spending puts a break on firm growth, leading to a size distribution skewed towards smaller firms. Trade and innovation are not independent; they interact in significant ways. A reduction in trade costs, for example, tends to stimulate innovation, because it allows firms to become larger, thus making it easier for them to bear the fixed costs of R&D.

The framework developed in this policy report emphasises this complex interaction

1. See www.efige.org, and footnote 2.

between a firm's decision to export and its decision to innovate. Different barriers – trade costs, innovation costs and tax distortions – affect these decisions, and ultimately determine a country's firm size distribution. The model we put forward is able to identify which barriers explain the relative absence of large firms in some European countries. The framework is then used to quantitatively estimate the returns from reducing the different barriers. It thus provides a useful tool for practitioners interested in understanding which policies are likely to be more beneficial in terms of stimulating firm growth. But the use of the model developed in this policy report goes beyond identifying what drives differences in the firm size distribution across European countries. It is also able to analyse some of Europe's pressing economic issues, such as the impact of a possible breakup of the euro area.

An important conclusion is that in order to identify the barriers to firm growth, a model is needed that jointly analyses trade and innovation. For example, if trade were to be ignored, the model would predict that both Italy and Spain have high innovation costs. However, once trade is introduced, the model finds that the high proportion of small firms in Italy is mainly due to high innovation costs, whereas in Spain it is due to a combination of high trade and high innovation costs. In other words, if Italy wants to reduce barriers to firm growth, it should mainly focus on promoting innovation, whereas in Spain the emphasis should also be on reducing trade costs and improving access to international markets.

Although this gives some indication about which barriers to firm growth different countries face, it does not say anything about the expected magnitude of the effects of different policies. How does reducing trade costs compare in terms of effectiveness to reducing innovation costs or reducing labour taxes? To address this question, the policy report estimates the effect on firm growth and the firm size distribution of a one percent drop in the different barriers (innovation costs, trade costs and taxes). In nearly all countries, reducing innovation costs has a much greater impact than reducing trade costs. On average, a one percent reduction in innovation costs is predicted to lead to an approximately 1.2 percent increase in firm growth, whereas a one percent drop in trade costs would increase firm growth by around 0.6 percent. This implies that policymakers, who need to find a trade-off between the reduction of certain barriers and the potential returns from doing so, would achieve a much greater impact by focusing on reducing the barriers to innovation.

Europe is in the midst of the most severe economic crisis since the Great Depression. Fiscal austerity programmes are biting hard. The breakup of the euro area, once considered a far-off doomsday scenario, is becoming a real possibility. Unfortunately, few models are able to shed light on the economic impact of these shocks. The framework developed in this policy report is well equipped to analyse these questions. In a first application, it estimates the effect of a 20 percent drop in government expenditure on R&D in Spain. Although this drop only amounts to 0.1 percent of GDP, the model predicts it will lead to a welfare drop in consumption of 2.7 percent. In a second application, the prospect of a return to national currencies is considered. Richard Baldwin has estimated this would lead to a drop in trade of 10 percent. Taking this number, the model predicts that abandoning the common currency would result in a welfare drop in consumption of between 7 percent and 15 percent. Larger countries, such as Germany, have larger domestic markets, and would lose less (around 7 percent), compared to smaller countries, such as Austria, which rely more on international trade, and would thus lose more (around 15 percent). This estimate, already large, should be viewed as a lower bound, since it only captures the negative effect euro-area breakup would have on trade flows, thus ignoring many other potential impacts.

1 Introduction

Large firms are more productive and more profitable than their more modestly-sized counterparts. They also pay higher wages and are more competitive in international markets. Not surprisingly, economically more successful countries have a greater share of large firms. In line with this picture, the firm size distribution in Europe differs significantly in different countries. In the seven countries analysed via the EFIGE (*European Firms in a Global Economy*) dataset, Italy and Spain have smaller shares of large firms (in terms of employees), compared to countries such as France, Germany or the United Kingdom (the other countries covered by the EFIGE dataset are Austria and Hungary[2]). Given the importance of large firms for a country's economic performance, Italian and Spanish policymakers should ask themselves what is keeping their medium-sized businesses from growing further. Once the barriers to company growth are identified, policymakers in those countries should act to reduce them.

Existing economic research provides some clues about what the barriers to firm growth might be. Some authors highlight that trade costs are key (Eaton and Kortum, 2002; Melitz, 2003; Di Giovanni, Levchenko and Ranciere, 2011). Countries that face higher barriers to trade, because of more restrictive trade policies or higher transport costs, provide fewer opportunities for businesses to become large. Others argue that the capacity of firms to innovate and therefore grow is important (Acemoglu and Cao, 2010; Luttmer, 2007, 2010). The relative absence of R&D spending puts a break on firm growth, leading to a firm size distribution skewed towards smaller firms. Still others cite size-dependent policies related to taxation, regulation and enforcement as possible explanations for differences in firm size distributions (Restuccia and Rogerson, 2008; Schivardi and Torrini, 2008). In countries where taxes or subsidies benefit smaller firms, one would expect a relative absence of larger firms.

2. The EFIGE dataset, prepared in the context of the EFIGE project, asked a total of 14,444 firms spread across seven countries about their performance, their modes of internationalisation, their employment decisions, their financing structure and their competitive environment, among other topics. Data was collected in 2010 and is representative of manufacturing sectors in each country. The countries covered are Austria, France, Germany, Hungary, Italy, Spain and the United Kingdom. The EFIGE project received funding from the European Union's Seventh Framework Programme, and from UniCredit Group. For details, see www.efige.org.

These different explanations are not mutually exclusive; they interact, and therefore cannot be analysed separately. For example, lower trade costs may allow firms to start exporting, resulting in them becoming larger. This may facilitate innovation, because larger firms can more easily bear the fixed costs of R&D. The link between innovation and exporting has been well documented in the literature. Lileeva and Trefler (2010) find a strong relationship in Canada, during the trade liberalisation with the United States. Bustos (2011) confirms this for Argentine firms, while Van Biesebroeck (2005) and De Loecker (2007) report that exporting increases productivity in, respectively, sub-Saharan Africa and Slovenia. As shown by Trefler (2004), the productivity gains associated with lower trade costs hold both at the firm level and at the aggregate industry level. Given this evidence, it seems important to analyse the joint impact of trade costs, innovation costs and other distortions on a country's firm size distribution. This is key if we want to identify the barriers keeping firms in some countries from becoming larger.

We start by documenting some of the basic stylised facts related to trade, innovation and firm size in the seven European countries covered by the EFIGE dataset. Based on Piguillem and Rubini (2012), we then propose a simple multi-country framework to analyse the interplay between trade, innovation and firm size. We calibrate the model using the EFIGE dataset, and show that it does a good job of accounting for the main differences between different European countries.

We then use our calibrated structural model as a tool for policy analysis. An important conclusion is that analysing trade and innovation independently leads to misleading results. In a closed economy model with innovation, we would conclude that both Italy and Spain have innovation costs that are relatively high. In our framework, however, we find that the high proportion of small firms in Italy is mainly due to high innovation costs, whereas in Spain it is due to a combination of high trade and innovation costs. In other words, if Italy wants to reduce the barriers to firm growth, it should focus on promoting innovation, whereas in Spain the emphasis should also be on reducing trade costs and improving access to international markets.

Although this gives some indication of the barriers to firm growth that different countries face, it does not say anything about the expected magnitude of the effects of different policies. To quantify these policies, we compare the effect on firm growth and on the firm size distribution of a one percent cut in the different costs faced by firms (innovation costs, trade costs, and taxes). We find that the effect on firm growth of reduced innovation costs is double that of reduced trade costs. Therefore, if reducing innovation costs and reducing trade costs are equally easy, policymakers should first focus on innovation costs, since the expected returns are substantially greater.

In light of the current economic crisis, we also apply our framework to analyse the effect of austerity measures and a potential breakup of the euro area. The cuts in public incentives for R&D in Spain are predicted to reduce consumption by 2.7 percent. As for the euro, abandoning the common currency would lead to a drop in consumption of 7 to 15 percent. This estimate should be viewed as a lower bound, since it only captures the negative effect such a breakup would have on trade flows, thus ignoring many other impacts.

The rest of the report is organised as follows. Section 2 presents the main stylised facts for the seven EFIGE countries. Section 3 sketches the multi-country framework of Piguillem and Rubini (2012). Section 4 calibrates the multi-country model and identifies the country-level innovation costs, trade costs and taxes that can account for the differences in the firm size distributions across countries. Section 5 presents a number of counterfactual exercises of interest for policy makers. Section 6 analyses the impact of the current economic crisis. Section 7 concludes.

2 Exports, R&D and the size of firms

In this section we compare the firm size distributions of different European countries, and highlight differences between exporting and non-exporting firms. We also provide evidence of the interaction between innovation and exports. The data for all figures comes from the EFIGE database. Following Altomonte *et al* (2012), we exclude firms that do not export but undertake some other international activity such as importing or that are part of a multinational group.

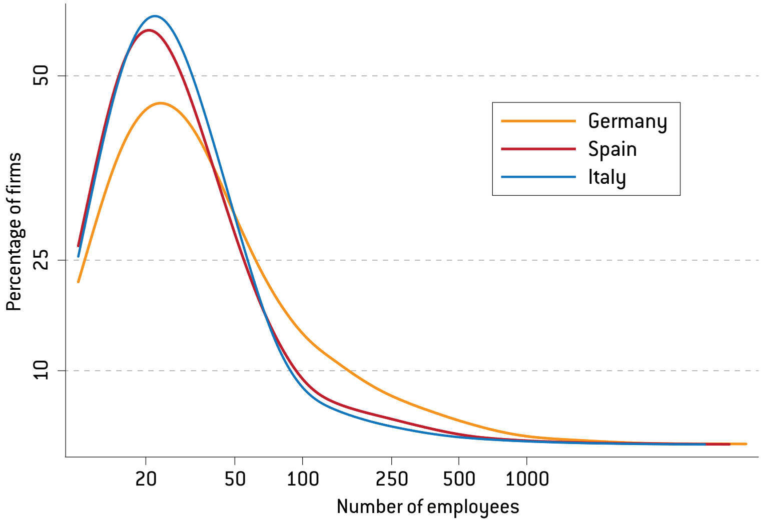
2.1 Stylised facts

Fact 1: There are big differences in the size of firms across Europe.

Figure 1 shows the firm size distributions in Germany, Italy and Spain. One feature stands out: Italy and Spain have higher densities of small firms, whereas Germany has more medium-sized and large firms. The average firm size in Spain and Italy is, respectively, 49.3 and 42.7 employees, compared to the significantly larger average size of 76.4 employees in Germany. That Spain and Italy are different from other countries can be further seen in Figures 2 and 3. Indeed, the firm size distributions in the other countries analysed in the EFIGE project (Austria, France, Hungary and the UK) are similar to Germany's. The same holds true for the average firm sizes, except for the UK, where firms tend to be substantially larger. More specifically, the average number of employees per firm is 83.8 in Austria, 85.8 in France, 76 in Hungary and 119.2 in the United Kingdom.

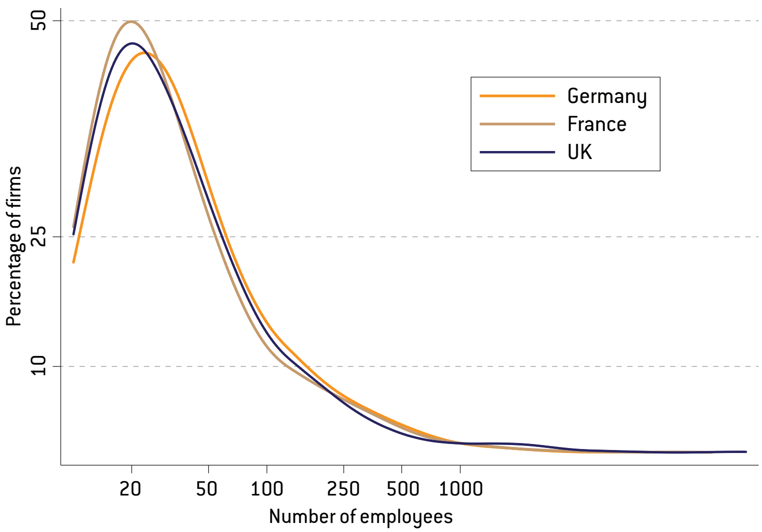
As we know from *The Happy Few* policy report (Mayer and Ottaviano, 2007), it is the really large firms that make most of the difference for a country's performance. To see if the differences between countries identified in the previous figures carry over to that privileged groups of large firms, Figure 4 represents the firm size distribution in a slightly different way: the vertical axis shows the proportion of firms (in natural logs)

Figure 1: Firm size distribution in Spain, Italy and Germany



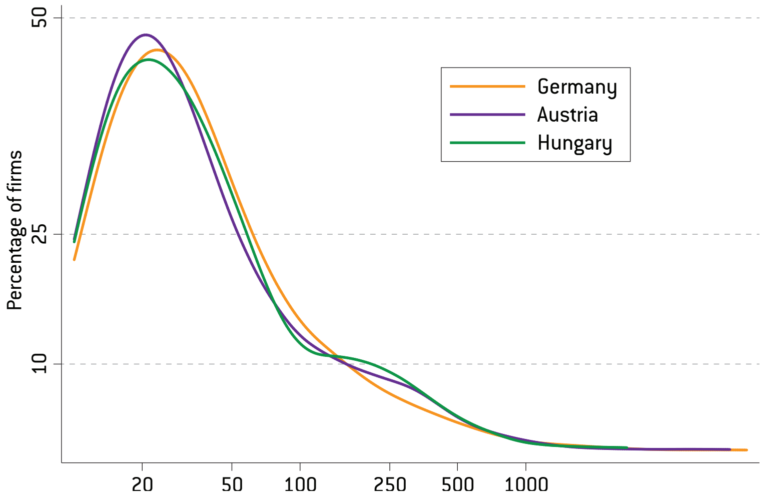
Source: Authors' calculations from the EFIGE dataset.

Figure 2: Firm size distribution in Germany, France and the UK



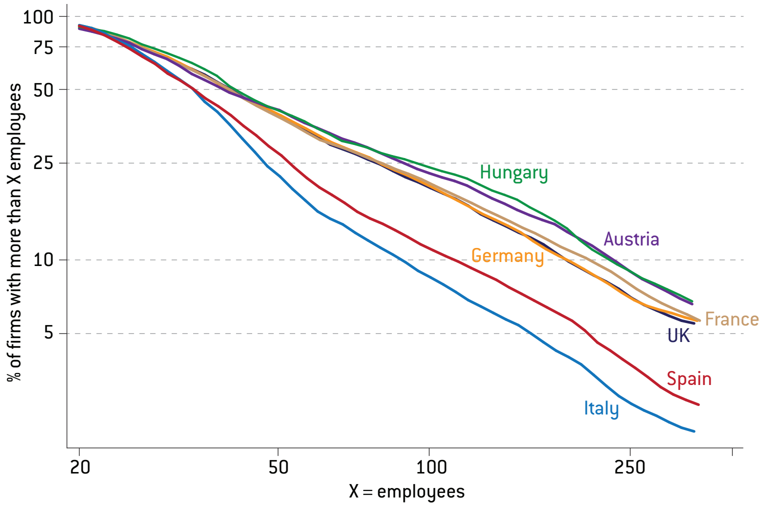
Source: Authors' calculations from the EFIGE dataset.

Figure 3: Firm size distribution in Germany, Austria and Hungary



Source: Authors' calculations from the EFIGE dataset.

Figure 4: Firm size distribution in different European countries

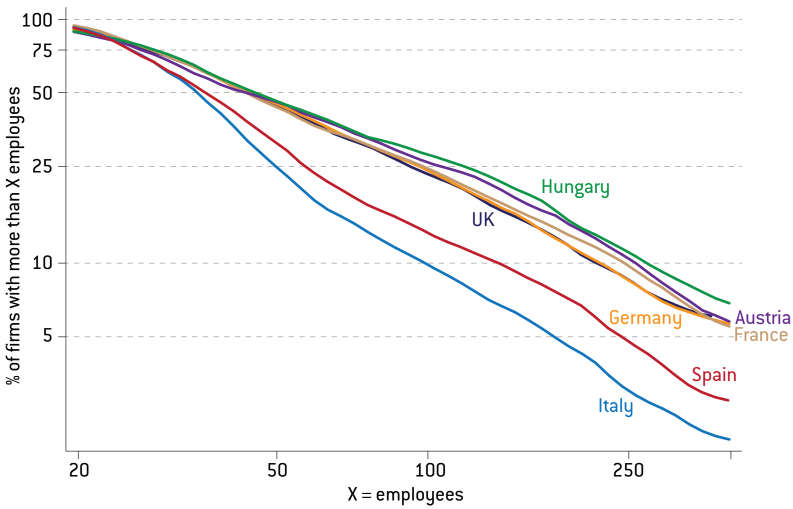


Source: Authors' calculations from the EFIGE dataset.

that is larger than the firm size (also in natural logs) given on the horizontal axis. Although Figure 4 represents exactly the same information as in the previous figures – for example that German firms on average are larger than Spanish firms – it emphasises differences in the upper tail of the distribution, ie, in each country's share of very large firms. As can be seen, Italy and Spain are clearly below the other countries for high values on the horizontal axis, indicating a relative absence of very large firms. The same information is reported in Table 1, where we see that the share of firms with more than 250 employees is 4.8 percent in Italy and 5.2 percent in Spain, compared to 11 percent in Germany.

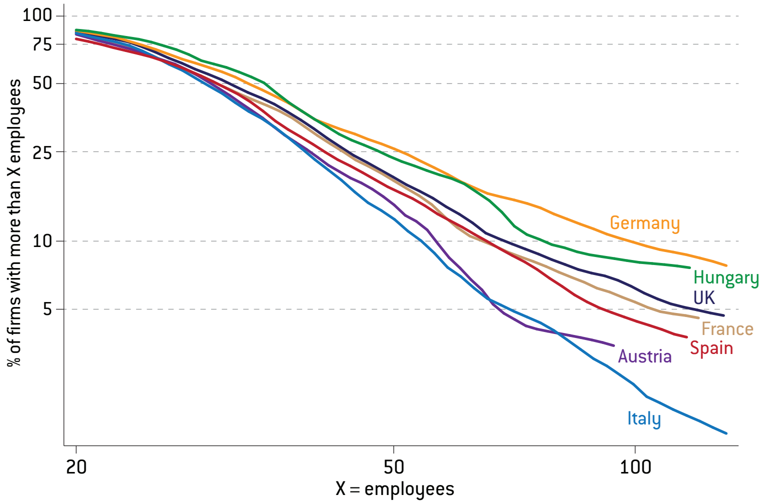
Figures 5 and 6 present the same data, but now separating exporting from non-exporting firms. While exporters follow the same pattern as that shown by Figure 4, the differences between Italy and Spain and the other countries for non-exporters are less clear-cut. This suggests that international trade is key for understanding the differences in the firm size distributions in different countries.

Figure 5: Exporters' size distribution in different European countries



Source: Authors' calculations from the EFIGE dataset.

Figure 6: Non-exporters' size distribution in different European countries



Source: Authors' calculations from the EFIGE dataset.

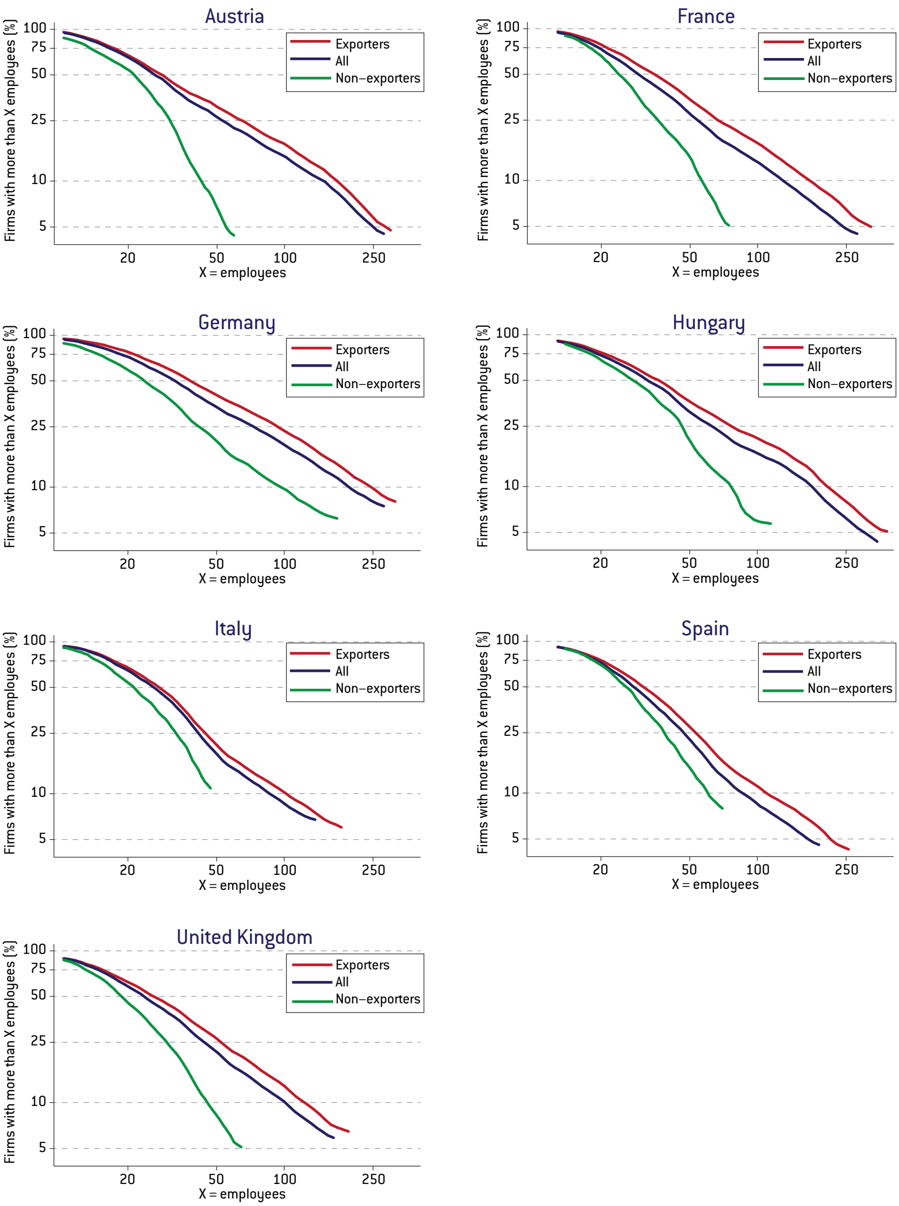
Table 1: Firm share by size class

Country	10 to 19 employees	20 to 49 employees	50 to 249 employees	More than 250 employees
Austria	30.3 %	36.0 %	22.8 %	10.9 %
France	32.0 %	39.0 %	21.1 %	7.9 %
Germany	23.5 %	38.4 %	27.3 %	10.7 %
Hungary	29.3 %	35.8 %	24.7 %	10.2 %
Italy	34.1 %	46.4 %	14.5 %	5 %
Spain	36.0 %	44.1 %	14.6 %	5.3 %
United Kingdom	30.9 %	38.9 %	25.0 %	5.1 %

Fact 2: Large firms tend to export more.

Another established fact, emphasised by Bernard and Jensen (1999), and further documented by Mayer and Ottaviano (2007), is that larger firms tend to export more. In Figure 7 we use the EFIGE data and compare the size distributions of exporting and non-exporting firms in different countries. As in Figure 4, the horizontal axis shows

Figure 7: Size distribution of exporting firms in different European countries



Source: Authors' calculations from the EFIGE dataset.

firm size (in logs) and the vertical axis shows the proportion of firms (in logs) being larger than that size shown on the horizontal axis. As expected, exporting firms in all countries are on average larger than non-exporting firms. This is reflected by the higher curve for exporters than for non-exporters in all countries.

Fact 3: Exporting firms are more productive and more profitable.

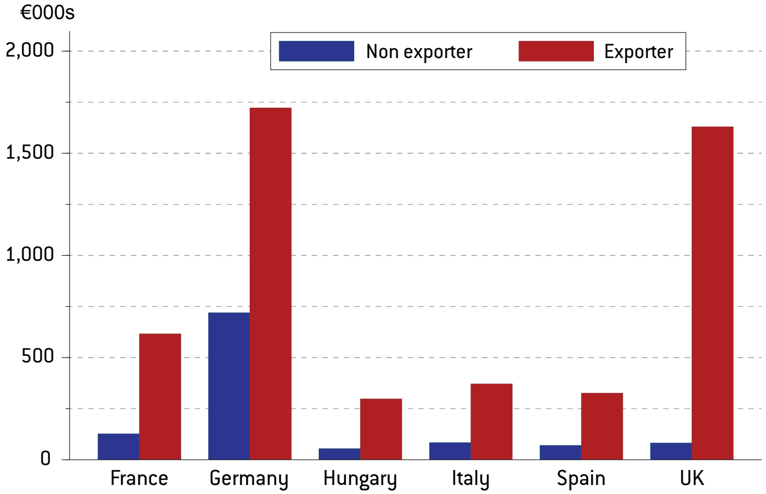
A third established fact is that exporting firms are more productive and more profitable than non-exporting firms (Mayer and Ottaviano, 2007). We here document these same stylised facts in the EFIGE dataset. Figure 8 plots the average profits in thousands of euros for exporters and non-exporters in the countries covered by EFIGE[3]. A clear pattern emerges, with exporters having higher average profits than non-exporters in all countries. Those countries in which firms have relatively high reported profits (Germany and the United Kingdom) correspond to countries for which figures are available only for a subgroup of firms because of problems with Amadeus data, the quality of which is variable across countries (and particularly poor for Germany and the United Kingdom)[4]. Larger firms were more overrepresented in Germany and the UK, explaining why average profits are higher. Figure 9 shows average total factor productivity (TFP) for all countries by export status, as computed by Altomonte *et al* (2012) using the EFIGE data[5]. As expected, exporters are on average more productive than non-exporters in all countries: 18.5 percent more productive on average. There are substantial differences between countries, with the productivity gap ranging from 50.5 percent in Hungary to 8.6 percent in Spain.

2.2 The interaction between innovation and exports

The existing literature on endogenous firm size distributions has typically focused either on closed-economy models with innovation (Acemoglu and Cao, 2010; Luttmer, 2007, 2010) or on open-economy models without innovation (Eaton and Kortum, 2002; Melitz, 2003). In the former case, differences in the firm size distribution are

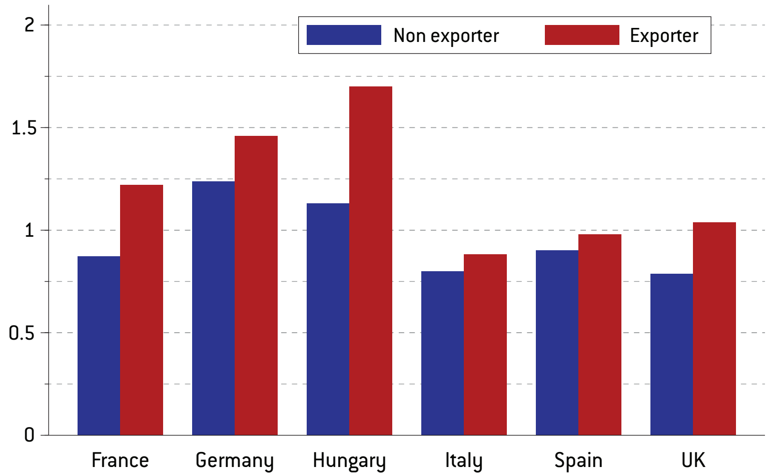
3. We use the Amadeus dataset, publised by Bureau van Dijk, which mainly reports balance sheet data, to complement the EFIGE survey data. See https://amadeus.bvdinfo.com/. Austria is not included in Figure 8 because Amadeus data only covers 6 percent of the firms in the survey.
4. Compared to an average coverage of 58 percent of firms, coverage for Austria, Germany and the UK was, respectively, 7 percent, 28.5 percent and 22.3 percent. Coverage for the other countries was 92 percent for France, 64.8 percent for Hungary, 94 percent for Italy and 88 percent for Spain.
5. As in the previous figure, there were substantial differences in coverage for different countries. Austria is excluded for the reasons stated above.

Figure 8: Average profits by export status



Source: Authors' calculations based on the EFIGE dataset/Amadeus.

Figure 9: Average TFP by export status



Source: Authors' calculations based on the EFIGE dataset/Amadeus.

accounted for primarily by differences in innovation, whereas in the latter case they come from differences in openness. However, as we know from both the empirical and the theoretical literature, there are significant interactions between trade and innovation (Constantini and Melitz, 2007; Lileeva and Trefler, 2011; Bustos, 2011; Yeaple, 2005; Atkeson and Burstein, 2010; Desmet and Parente, 2010; Rubini, 2011; Crespo, 2012; Piguillem and Rubini, 2012). Consistent with this, the EFIGE database shows a strong relationship between a firm's export intensity and its research intensity, as highlighted by the next fact.

Fact 4: Exporting firms tend to innovate more.

Using firm-level data from EFIGE, Table 2 shows a simple regression of innovation (measured by the log of R&D as a share of sales) on exports (measured by the log of exports as a share of sales). As expected, the relationship between exports and innovation is positive for all countries, with the exception of Hungary, where the relation is statistically insignificant.

Table 2: Trade and innovation

Dependent variable: log(R&D/Sales)							
	Austria	**France**	**Germany**	**Hungary**	**Italy**	**Spain**	**U.K.**
log (Exports/Sales)	0.12	0.06*	0.12**	0.00	0.11**	0.10**	0.14**
	(0.07)	(0.025)	(0.033)	(0.091)	(0.024)	(0.028)	(0.028)
log (Employees)	-0.05*	-0.04	-0.09**	-0.34**	-0.17**	-0.23**	-0.20**
	(0.067)	(0.027)	(0.027)	(0.085)	(0.028)	(0.032)	(0.034)
Constant	1.10**	1.26**	1.56**	2.64**	1.71**	2.02**	1.68**
	(0.305)	(0.125)	(0.146)	(0.460)	(0.118)	(0.136)	(0.154)
Observations	164	961	915	79	1270	805	819

**p<0.01, *p<0.05

In light of these different stylised facts, this policy report will analyse the joint effect of trade and innovation on the firm size distribution in different European countries. The main aim is to explore the relative contribution of trade costs and innovation costs to the distribution of firm sizes. Given the major differences in tax distortions from country to country, we will also take those into account, as they are likely to affect the results.

3 Framework

To understand which differences in each country's structure account for the observed differences in firm size distributions, we need a theoretical framework that we can then take to the data. Piguillem and Rubini (2012) develop such a framework, and this section draws on their results. We here present its most salient features, abstracting from technical details, which are further discussed in the Technical Appendix (page 39).

The model follows the standard Melitz (2003) framework, and is consistent with empirical Fact 1 through Fact 4 in the previous section, as identified in the EFIGE database. That is, in equilibrium the model generates (i) large differences in firm size distributions across European countries; (ii) a size premium of exporters over non-exporters; (iii) a profitability and productivity premium of exporters over non-exporters; and (iv) an innovation premium of exporters over non-exporters.

The model is dynamic and time is continuous. There are seven countries, corresponding to the seven countries surveyed by the EFIGE project. There is a large number of individuals in each country supplying labour and consuming goods produced by domestic and foreign firms. Each good is produced monopolistically by one firm. There is entry and exit of firms. The numbers of goods (and firms) differ in each country and are determined in equilibrium.

Each firm takes the following decisions:

- *Entry.* To enter, a firm must pay a fixed cost. Firms enter as long as this cost is lower than expected profits. All new firms produce with the same technology.

- *Pricing.* A firm observes the demand for its good and sets its price and quantity to maximise profits.

- *Exporting.* If a firm has not exported in the past, exporting requires a one-time sunk cost.

- *Innovating.* Firms make investments that increase their future productivity. We describe this process in further detail below.

Innovation is a key element of the model. By paying a fixed cost, firms can reduce their marginal cost. Thus, the greater the output, the greater the incentive to innovate, since the gains from reducing the marginal cost are greater. Output will be high when (i) the price set by the firm is low or (ii) the demand for the good is high. Firms with low marginal costs charge lower prices, so that innovation allows firms to reduce their prices. This further increases output and the incentive to innovate. The demand will also be high when the income of the consumers is high or when the price of all other goods is high.

Innovation costs differ in different countries by a scale parameter, κ_I. This parameter plays an important role in our numerical analysis.

Key parameter 1: Innovation cost parameter κ_I. *If the value of κ_I is 1 percent higher in country A than in country B, then to improve productivity by a certain amount, a firm in country A requires 1 percent more workers compared to an identical firm in country B.*

A second key element of the model is export costs. If a firm wants to export, it must be pay a sunk cost, κ_x and a variable transport cost, τ_x (Melitz, 2003). The sunk export cost κ_x is paid one time and covers all destinations. Therefore, once a firm starts exporting, it will continue to do so in all subsequent periods, and once it exports to one destination, it will do so to all destinations. The sunk export cost κ_x is different in different countries.

Key parameter 2: Export sunk cost parameter κ_x. If *the value of κ_x is 1 percent higher in country A than in country B, becoming an exporter in country A requires 1 percent more workers than in country B.*

As is standard in the trade literature, we model the variable transport cost, τ_x as an iceberg cost. That is, to deliver one unit of a good, $(1+\tau_x)$ goods must be shipped. Transport costs are different in different countries. These differences may reflect, for example, the more or less central geographic location of the different countries. To understand differences in the firm size distributions, the transportation cost τ_x is another key parameter.

Key parameter 3: Variable export cost τ_x. *If the value of τ_x is 1 percent higher in country A than in country B, delivering one unit to a foreign consumer requires 1 percent more units to be shipped from country A than from country B.*

Innovation and export decisions interact. Consider two identically productive firms, but one exports while the other sells only to the local market. In that case, the exporting firm will be larger than the non-exporter, and will more easily bear the fixed cost of innovation. As a result, exporting firms will grow faster than non-exporting firms, a stylised fact for the United States observed by Bernard and Jensen (2001). Moreover, we show that exporters grow at a rate that is independent of their size.

As is well known from the literature (Restuccia and Rogerson, 2008), the firm size distribution depends not just on innovation and export costs, but also on tax distortions. In the model we allow for both corporate (profit) taxes, τ_π, and labour taxes, τ_l. Those tax rates are different in different countries.

Key parameters 4 and 5: Corporate tax rate τ_π and labour tax rate τ_l.

The dynamics of the model work as follows. Consider an entrepreneur deciding whether to enter the market. She will do so if the entry cost does not exceed her expected lifetime discounted profits. She then starts off with a small firm (in terms of productivity, sales and employment), and in each period sets aside part of the profits for innovation. This allows her firm to grow. At some point, it will become worthwhile to pay the sunk export cost and start exporting. This implies a large (lumpy) increase in market size, and consequently an increase in her innovation and growth rates. At any time, the firm may die, causing exit. To keep things simple, we assume this results from an exogenous shock that the entrepreneur cannot prevent.

Note that innovation, entry and exit imply heterogeneity in productivity and therefore a non-degenerate endogenous firm size distribution. In the next section we map the distribution in the data into the distribution in the model to extract the different parameter values for the different countries. This will help us to identify what generates differences in the firm size distribution in different countries. It will also allow us to run a number of counterfactual policy experiments.

4 Calibration and results

In this section we discuss how we use the EFIGE data to determine the different parameter values of our model. We then discuss what we can learn from the differences in the estimated parameter values across countries. We also emphasise the importance of having a framework that jointly estimates the different factors that affect a country's firm size distribution.

4.1 Calibration and parameter values

We focus on those parameters that are most relevant for the exercise. For further details, we refer the interested reader to Piguillem and Rubini (2012). Some parameter values are taken directly from the literature or the data, whereas others are calibrated to moments in the data. The calibration targets are given in Table 3 and the calibrated parameters in Table 4.

The targets make extensive use of the information in the EFIGE dataset. For a country's size, we take total employment in the EFIGE dataset, where we normalise Germany to 1. Labour tax rates are from McDaniel (2007). Profit taxes come from the *Doing Business 2012* report[6]. We obtain firm death rates in the manufacturing sector from Eurostat.

Trade and innovation costs are set to target certain moments in the EFIGE data. The variable trade cost τ_x is country-specific and is set to match the ratios of exports to total sales[7]. Since we only know the total exports, not exports by destination, we use a common τ_x for exporters in a given country exporting to any destination. The sunk export cost, κ_x , determines the extensive margin, that is, the number of firms that export. We set it to match the number of firms that export in each country. Lastly, the

6. http://www.doingbusiness.org/data
7. This requires aggregate data on exports and revenues. Unfortunately, while the EFIGE dataset collects information on the share of exports to total revenues at the firm-level, it does not report the data on revenues separately. To work around this we compute an average of trade volumes using employees as weights. This would yield the true aggregate export volume if employees would be perfectly correlated with revenues.

Table 3: Calibration targets and relevant parameters

Country	Employment	Export volume	Exporting firms	Slope	Profit tax	Labour tax	Firm death
Austria	562,464	44%	82%	1.14	15%	12%	4%
France	2,903,820	27%	71%	1.11	8%	10%	6%
Germany	5,739,365	20%	65%	1.16	19%	10%	6%
Hungary	607,097	40%	74%	1.13	15%	9%	8%
Italy	3,555,052	33%	77%	1.42	23%	14%	6%
Spain	2,010,424	21%	68%	1.27	1%	9%	6%
UK	3,768,663	26%	73%	1.06	23%	15%	8%
Parameter	L	τ_x	κ_x	κ_I	τ_π	τ_l	δ

Source: Authors' calculations from EFIGE Dataset and Piguillem and Rubini (2012).

innovation cost, κ_I, which is also country-specific, is set to match the slope of the distribution of exporting firms (with more than 30 employees). Here again, we normalise Germany's innovation cost to 1.

Table 4: Parameter values

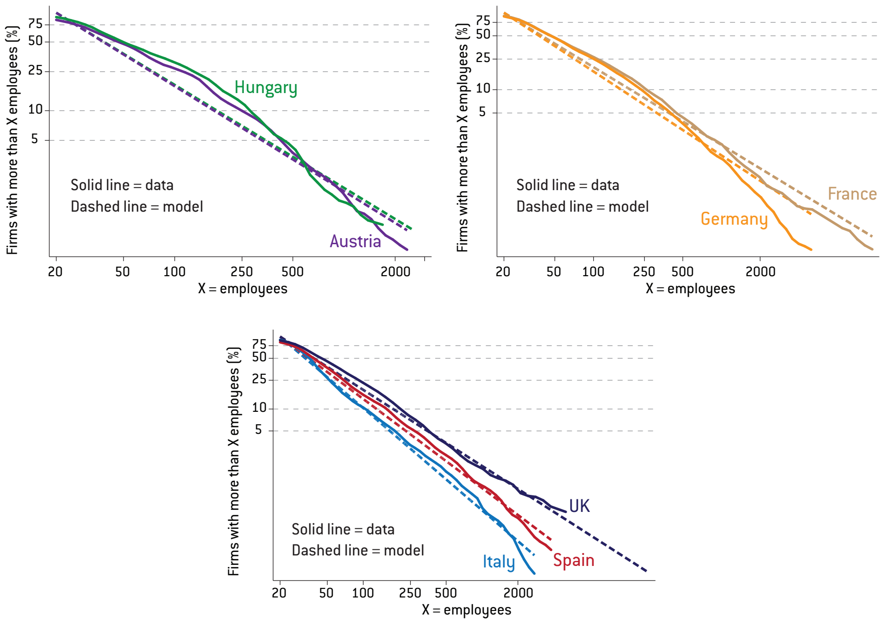
Country	Innovation cost (κ_I)	Sunk trade cost (κ_x)	Variable trade cost ($1+\tau_x$)
Austria	1.91	2.50	1.41
France	1.08	1.35	1.04
Germany	1.00	1.00	1.00
Hungary	0.99	2.28	1.48
Italy	1.47	1.92	0.95
Spain	1.12	1.03	1.58
UK	0.75	1.21	0.96

Source: Piguillem and Rubini (2012).

Before further analysing the calibrated parameters, it is useful to discuss the calibration targets in more detail, because they provide valuable information that will help us interpret our findings. As Table 3 shows, several facts stand out. There are major differences in export shares in different countries. While exports make up 44 percent of revenues for Austrian firms, that figure drops to 21 percent in Spain. Similarly, while 77 percent of Italian firms export, that share drops to 65 percent in Germany. The relatively high share of Italian firms exporting was already highlighted in an earlier EFIGE policy report by Barba Navaretti *et al* (2011). As for the slope of the distribution of exporting firms, a lower negative number indicates a steeper slope, and therefore a smaller proportion of larger firms exporting. Consistent with this, in Italy and Spain the typical exporter is relatively smaller, whereas in France and the UK there are many large exporting firms. Taxes also differ significantly from country to country. Profit taxes, for example, are relatively high in the United Kingdom and Italy, they are low in France, and practically zero in Spain[8].

Figure 10 shows the match of the distribution of exporters. By construction, the slope in the model is equal to the slope of a linear fit in the data, so it is not a surprise that the fit is good.

Figure 10: Model and data firm size distributions



Source: Authors' calculations from the EFIGE dataset.

8. This is the *effective* tax rate calculated in the *Doing Business* report for 2012 (the only year we have data for). These rates do not have an effect on the calibration of our parameters, only on the counterfactual exercises that follow.

4.2 Discussion of parameter values

We now discuss what we can learn from the estimated differences in parameter values in different countries in Table 4. As mentioned before, all parameters are relative to Germany.

Innovation costs κ_I. From Table 4 we see that the United Kingdom has the lowest cost of innovation; Germany, France, Spain and Hungary come next; and Italy and Austria have the highest. While most of these values are expected, some may come as a surprise. For example, Spain's innovation costs, while higher than Germany's, are substantially lower than Italy's or Austria's. This seemingly contradicts the perception that Spain is a country in which innovation is costly. It also goes against the prediction of standard closed-economy models, which would require innovation costs to be high in order to explain the relative absence of large firms in Spain. To resolve this apparent contradiction, our open-economy model shows that what is relatively costly in Spain are trade costs (58 percent more than Germany's, the highest in the sample) rather than innovation costs. High trade costs imply smaller firms, and therefore fewer benefits from innovation. This suggests that if innovation in Spain is low, it is due primarily to high trade costs, and to a lesser extent high innovation costs. High trade costs reduce the returns from innovation. This, added to the high cost of innovating, leads to low innovation rates in equilibrium.

Trade costs τ_x. As already mentioned, marginal trade costs are highest in Spain. This is partly offset by a relatively low sunk export cost. Austria and Hungary also have high export costs. Italy stands out as a country that is particularly good at exporting. Its variable trade costs are low. This explains why so many Italian firms export and why each exporting firm exports so much. It provides micro-foundations for Barba Navaretti *et al* (2011), who find that many Italian firms export, and when they export, they do so in large amounts. The difference between Italy and Spain may also have to do with their geographical location.

An important conclusion that we may extract from the calibration exercise is that the source of misallocation that accounts for the high share of small firms in Italy and Spain is different. Italy has high innovation costs and low trade costs, whereas Spain has both high trade and innovation costs. We can therefore conclude the following:

Finding 1 *The relative absence of large firms in Italy is, in our framework, mainly due to high innovation costs; the relative absence of large firms in Spain is due to a combination of both high innovation and trade costs.*

4.3 The importance of accounting for all factors

The example of Italy and Spain suggests that it is important for all factors (innovation costs, trade costs and taxes) to be taken into account when comparing firm size distributions in different countries. Not doing so would produce misleading results. To see this more clearly, consider what the model would predict if we were not to allow for trade. Table 5 compares the implied innovation costs in our model with those of a closed-economy model. Take the case of Italy. To account for its firm size distribution in a closed-economy setting, the model would predict innovation costs to be 18 percent higher than in Germany. Once we go to an open-economy framework, this figure increases to 47 percent. Given that Italy is good at exporting, its estimated innovation costs must increase to keep its firms from becoming too large.

Following this argument, one would expect that, when going from a closed to an open economy, the estimated innovation costs should increase in countries that are good at exporting and would decrease in countries that are not so good at exporting. However, in a country such as Spain, with high trade costs, the estimated innovation cost hardly decreases. This happens because of a market size effect. Opening up the economy to trade has a greater effect on Spain than on Germany, because the relative increase in the market size is larger for smaller economies. This mitigates the negative effect of Spain facing higher trade costs than Germany.

The importance of jointly analysing the different factors when trying to understand the firm size distribution is summarised by the following finding:

Finding 2 *Analysing differences in the firm size distribution in different countries abstracting from international trade, results in biased estimates that ignore the importance of market size.*

Table 5: Innovation costs in closed and open economies

Country	Slope		Growth rate		Innovation costs	
	Open	Closed	Open	Closed	Open	Closed
Austria	-1.14	-1.14	2.03%	2.03%	1.92	1.36
France	-1.11	-1.14	2.81%	2.77%	1.08	1.00
Germany	-1.16	-1.17	2.78%	2.76%	1.00	1.00
Hungary	-1.11	-1.17	3.71%	3.64%	0.99	0.76
Italy	-1.42	-1.46	2.37%	2.34%	1.47	1.18
Spain	-1.27	-1.33	2.52%	2.45%	1.12	1.13
UK	-1.06	-1.10	3.92%	3.84%	0.75	0.72

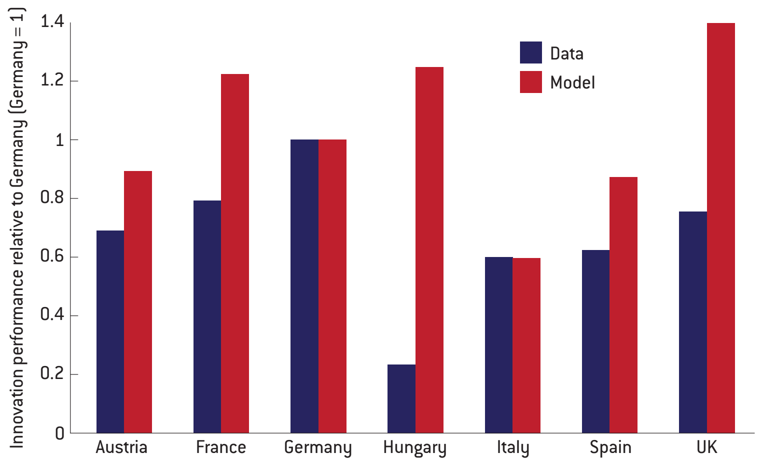
Source: Piguillem and Rubini (2012).

4.4 Model validation

Before using the model to carry out counterfactual policy analysis, it is important to see how well the theory captures the main characteristics of the economy. To do so, in this section we discuss the performance of the model in relation to a number of *non-targeted* aspects. In other words, we analyse if the model correctly predicts features in the data that we are not matching by construction. We highlight three such features. First, we study if innovation in the model is close to that in the data. We then analyse two different measures of labour productivity: wages and value added per worker.

Innovation. A problem with the theoretical notion of innovation is that it has no clear counterpart in the data. In the model, innovation can be understood as any expenditure that increases firm productivity. In the data, this includes research and development, organisational expenses, marketing expenses, etc. The EFIGE database reports information on the proportion of workers per firm dedicated to R&D activities, so we compare this with the proportion of workers involved in innovation in our model. There is a problem of missing data, because many firms have not reported their R&D employees. We exclude those firms from the analysis. Figure 11 shows the comparison of innovation in the model and data. Innovation is normalised to Germany's level, which matches the data by construction. Such normalisation is needed because R&D is only part of innovation. The results are strikingly good for all countries except the UK and Hungary. A reason why the model might fail for the UK is that many of these firms perform their R&D expenditures abroad, especially in the United States, as documented by Griffith *et al* (2006).

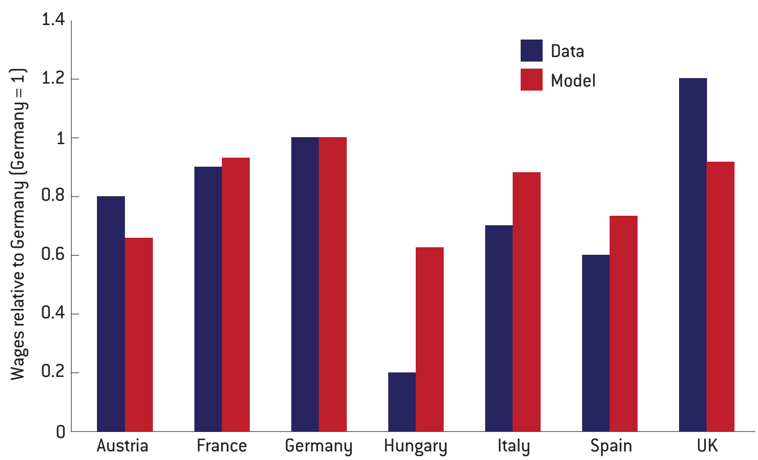
Figure 11: Innovation: model vs. data



Source: Authors' calculations.

Wages. Another non-targeted aspect by which we can evaluate the model is the difference in wages in different countries. Eurostat has information on the wage rate in each of these countries. In Figure 12, we compare these to the ones produced by the model in equilibrium. The fit is exceptionally good in all countries except Hungary.

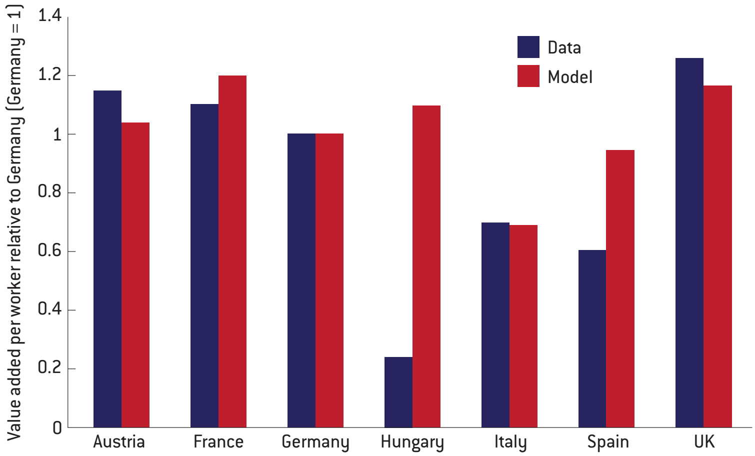
Figure 12: Wages: model vs. data



Source: Authors' calculations.

Value added per worker. The last non-targeted aspect with which we evaluate the model is value added per worker. The data comes from Eurostat. Once again, Figure 13 shows a good fit in all countries except Hungary.

Figure 13: Value added per worker: model vs. data



Source: Authors' calculations.

Overall, the finding that the structure of the model captures well many of the features of the economy that are not being matched by construction lends credibility to our theoretical framework. This is key, as it allows us to use our calibrated model to do policy analysis. This will be the focus of the next sections.

5 Improving firm growth

Given that a country's economic performance depends disproportionately on its largest firms, the relative lack of large firms in some European countries is an important policy concern. By jointly analysing the effect of different barriers we identified trade costs as the main barrier to firm growth in Spain, and innovation costs as the main barrier in Italy. Although this gives some idea of the areas in which policymakers should be acting if they wish to promote firm growth, it does not say anything about the different potential impact of different policies. The advantage of having a calibrated structural model is that it allows us to carry out counterfactual exercises that quantify these effects. In particular, in this section we will estimate the impact of a reduction in the different barriers (innovation costs, trade costs and taxes) on the growth rates of exporting firms and on the firm size distribution in different countries.

5.1 Exporter growth rates

Starting with a partial equilibrium approach, in which we fix aggregate variables such as wages and the firm size distribution, Table 6 shows the percentage change in the growth rates of exporters for a one percent reduction in innovation costs and a one percentage point reduction in the other barriers. All results are as expected: a reduction in any cost increases the growth rate of exporters. In quantitative terms, a reduction of 1 percent in the innovation cost κ_I has a substantially larger effect than a reduction in any of the other parameters (except in Austria, where a reduction in trade costs has a bigger impact). In order of declining importance, innovation costs are followed by variable trade costs, and then by taxes. For example, the growth rate of German exporters is predicted to increase by 1.19 percent when reducing innovation costs by 1 percent, by 0.42 percent when reducing variable trade costs, by 0.28 percent when reducing profit taxes, and by 0.11 percent when reducing labour taxes. We can therefore conclude the following.

Finding 3 *Reduced innovation costs have, in our framework, a substantially larger effect on the growth of exporting firms than reduced trade costs.*

Table 6: Counterfactuals in partial equilibrium: shocks to all countries

Change in	Austria	France	Germany	Hungary	Italy	Spain	UK
Innovation costs (κ_I)	1.16	1.19	1.19	1.22	1.16	1.17	1.24
Variable trade costs(τ_x)	1.24	0.62	0.42	0.21	0.69	0.68	0.49
Profit taxes(τ_π)	0.20	0.11	0.28	0.21	0.34	0.01	0.37
Labour taxes(τ_l)	0.13	0.11	0.11	0.10	0.14	0.09	0.16

Source: Author's calculations based on Piguillem and Rubini (2012).

This implies that policymakers, who need to secure a difficult trade-off between the reduction of certain barriers and the potential returns from doing so, would achieve a much greater impact when focusing on reducing the barriers to innovation.

We can do the same analysis in general equilibrium where we allow aggregate variables to change. Table 7 shows the general equilibrium effects of a 1 percent reduction in the different *German* frictions on growth of exporters in *all* countries. When taking into account general equilibrium effects, the results are similar in terms of their relative importance, but somewhat smaller in magnitude. Compare, for example, the effect of a 1 percent decrease in innovation costs κ_I in partial and general equilibrium, shown on row one of Table 6 and Table 7[9]. A 1 percent drop in innovation costs in Germany increases exporter growth of German firms by 0.84 percent in general equilibrium, compared to a higher 1.19 percent in partial equilibrium. The reason for this smaller effect is that in general equilibrium whenever exporter growth rates increase, exports increase, competition in the other countries becomes tougher, and profits decrease. This reduces the demand for German goods via an income effect. Consequently, exporter growth rates decrease, partially offsetting the initial rise.

Table 7: Counterfactuals in general equilibrium: shocks to Germany

Change in	Austria	France	Germany	Hungary	Italy	Spain	UK
Innovation costs (κ_I)	0.31	0.14	0.74	0.06	0-.04	-0.06	0.14
Variable trade costs(τ_x)	0.06	0.06	0.11	0.06	0.06	0.04	0.06
Sunk trade costs (κ_x)	-0.02	-0.02	0.02	-0.02	-0.02	-0.02	-0.02

Source: Piguillem and Rubini (2012).

9. We omit the results based on changes in taxes since the changes were too small.

The effect of a reduction in the sunk export cost is also interesting[10]. Maybe surprisingly, it lowers the growth rate of exporters. The intuition is that a smaller κ_x increases competition: if more firms become exporters, more firms become large. This reduces exporters' profits, and consequently their growth rates.

An additional aspect ignored by partial equilibrium analysis is the effect a reduction in barriers in Germany has on other countries. These are not negligible: in the case of export costs, the change in growth rates in the other countries is close to half the change in Germany. To describe how a shock in one country spills over to another, consider a reduction in innovation costs in Germany. As this increases German innovation levels, export growth rates and exports, firms in other countries face greater competition, reducing profits and growth rates. There is also a secondary effect via wages. Since the labour endowment is fixed, wages in the other countries decrease, which raises profits, and consequently growth rates. As we can see from Table 7, the wage effect dominates, so growth rates increase.

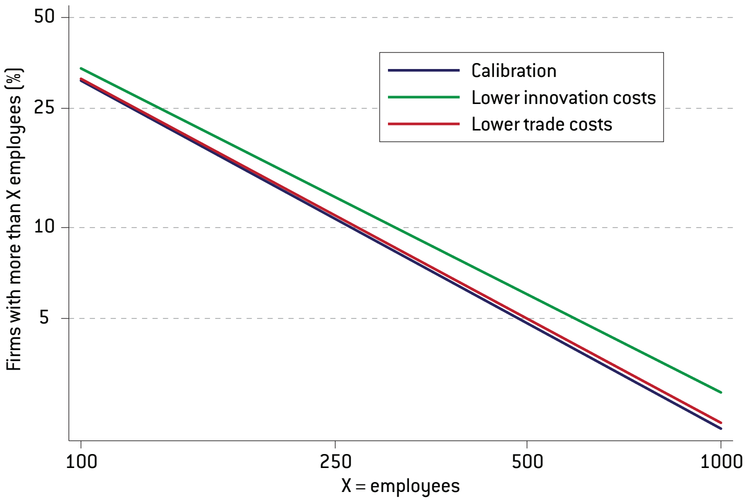
5.2 Slope of the distribution

Finding 4 *Reducing innovation costs has a greater effect on the firm size distribution than reducing trade costs.*

We next turn to how different shocks affect the firm size distribution in different countries. The slope of the distribution of exporters is inversely proportional to the growth rate of exporters. The counterfactual exercises decrease the innovation cost by 5 percent and the trade costs by 5 percentage points. We then compute how the distributions of exporting firms change. Figure 14 shows the difference in slopes computed under general equilibrium for Germany. As can be seen, the effect of a reduction in innovation costs is substantially larger than the effect of a reduction in trade costs. In the EFIGE survey, 10.7 percent of German firms have more than 250 employees. Reducing the innovation cost by 5 percent would increase that share to 12.64 percent, compared to an increase to 10.98 percent when reducing the trade cost by 5 percent.

10. We did not analyse its impact in Table 6, since it has no effect in partial equilibrium.

Figure 14: Counterfactuals in general equilibrium: effects on firm size distribution in Germany



Source: Authors' calculations.

6 Effects of the crisis

In the current economic crisis in Europe, there is great uncertainty about how different policy measures might affect the economy. Our structural model is equipped to quantify different possible policy scenarios. In this section we focus on two specific questions. How would a reduction in public spending on R&D affect productivity, consumption and welfare? And, maybe more importantly, what would be the impact of the collapse of the euro?

6.1 Reducing public expenditures on R&D

In Spain it has been estimated that government spending on R&D dropped by about 20 percent between 2009 and 2012[11]. In simulating this drop, we face two problems. The first is that innovation in the model covers not just R&D; the second is that we do not know how public spending in R&D affects private spending on R&D. To address the first problem, we assume that a fraction of innovation comes from R&D, and that fraction is such that the share of innovation relative to value added in the model corresponds to the share of R&D relative to GDP in the data. To be specific, in Spain the ratio of R&D to GDP was 1.39 percent in 2010. In the model, the ratio of innovation to value added was 2.86 percent. Accordingly, we assume that half of the innovation expenditures are R&D.

To tackle the second problem, we need to determine how a reduction in public expenditures affects firm-level R&D. According to the EFIGE data, the government finances about 34 percent of R&D in Spain. Assuming that private R&D remains unaltered, a 20 percent reduction in public R&D would therefore imply a drop in Spanish R&D of about 7 percent. Unfortunately, without a better theory of the effect of public R&D on total R&D, it is unclear what the effects on private R&D will be. On the one hand, public R&D may crowd out private R&D, in which case private R&D, would increase, mitigating the effect of the fall in public R&D. On the other hand, it is likely that there are complementarities between public and private R&D, so private R&D might

11. Spending decreased from €9.66 billion in 2009 and to €7.99 billion in 2012 (CCOO, 2012).

actually fall, increasing the effect of the drop in public R&D. Given that we do not have a precise idea of which effect is stronger, we take the naive view that private R&D remains constant. Since half of the innovation expenditure comes from R&D, the 7 percent drop in R&D therefore implies a 3.5 percent drop in overall innovation expenditure.

To match this 3.5 percent drop in innovation spending, the counterfactual exercise assumes an increase in the innovation cost κ_I by 0.96 percent. The model predicts that in steady state, Spanish value added would drop by 2.1 percent, while welfare would decrease by 2.7 percent in terms of consumption units. These are huge effects, given that the 3.5 percent drop in innovation spending corresponds to a mere 0.1 percentage point drop as a share of manufacturing GDP.

Finding 5 *The 20 percent drop in public R&D expenditures experienced in Spain reduced manufacturing value added by 2.1 percent and welfare (in consumption units) by 2.7 percent.*

6.2 Breakup of the euro area

While the breakup of the euro would lead to many unforeseen effects, we here focus exclusively on its impact on trade. Baldwin (2006) estimates that dropping the common currency would reduce trade volumes by up to 10 percent. To match this number, in our counterfactual exercise we increase variable trade costs τ_x so that each country's exports fall by 10 percent. We focus on variable trade costs, rather than sunk export costs, because exchange rate volatility is more likely to have a direct effect on the intensity of exports. Although the proportion of firms that export might also change, this is likely to be an indirect effect, in response to the overall drop in export intensity of firms.

We display our results in Table 8. Welfare, measured in terms of consumption units, would drop by between 4 percent and 7 percent. In terms of value added, the negative effects are of a similar order of magnitude. Not surprisingly, the countries that face the greatest losses are the countries with the smallest relative domestic markets: Austria and Hungary.

Finding 6 *A breakup of the euro would reduce welfare (in consumption units) by between 7 percent and 15 percent.*

Table 8: Breakup of the euro area

	Percentage change in		
Country	Transport costs	Welfare	Value added
Austria	9.87%	-15.22%	-11.76%
France	8.71%	-10.48%	-8.24%
Germany	4.29%	-7.30%	-5.75%
Hungary	6.79%	-11.06%	-8.42%
Italy	6.33%	-7.84%	-5.91%
Spain	3.27%	-7.30%	-5.74%
UK	6.09%	-7.35%	-5.63%

Source: Author's calculations based on Piguillem and Rubini (2012).

7 Conclusions and recommendations

This policy report has analysed the joint impact of innovation costs, trade costs and taxes on the firm size distribution in different European countries. Doing so has allowed us to understand why some countries, such as Italy and Spain, have relatively few large firms, compared to other countries, such as France, Germany and the United Kingdom.

To identify the barriers to firm growth, it is important to analyse the interaction between trade, innovation and growth. Firms can only bear the fixed costs of innovation when the market is large enough. One way of expanding the market is through international trade. A firm's decision to innovate and its decision to trade are therefore intimately linked. Piguillem and Rubini (2012) provide a framework that incorporates both channels. We calibrated their model to the EFIGE database with the objective of understanding what the barriers to firm growth are in the different European countries. We then quantitatively analysed which policies are likely to be more effective in breaking down those barriers.

The main conclusions of the quantitative analysis are as follows:

First, in Italy high innovation costs prevent firms from growing, though the costs of exporting are low. In contrast, Spanish firms do not achieve high growth rates because of a combination of high trade and high innovation costs. In as far as having large firms is desirable because of their higher productivity and profitability, this provides an indication to policymakers in these countries where the barriers to firm growth lie.

Second, ignoring trade when analysing firms' incentives to innovate may be misleading. In the case of Spain, for example, the low rate of innovation is partly due to the high trade costs. Facilitating access to foreign markets would therefore not only increase trade volumes, it would also lead to more innovation.

Third, the return on reduced innovation costs is in general greater than the return on reduced trade costs. Except in Austria, the impact on firm growth is greater when innovation costs drop. Policymakers, who need to find a trade-off between the reduction of certain barriers and the potential returns from doing so, would achieve a much greater impact by focusing on reducing the barriers to innovation.

In addition to analysing differences in the firm size distribution in different European countries, we have also used our model to study the quantitative impact of the current economic crisis on output and consumption. This allows us to state two more conclusions:

Fourth, fiscal austerity measures, such as the reduction in public spending on R&D, are likely to have large negative consequences. For example, the 20 percent drop in government expenditure on R&D in Spain (which corresponds to 0.1 percent of GDP) is predicted to reduce Spanish welfare by 2.7 percent.

Fifth, when focusing exclusively on the trade effects of a possible breakup of the euro area, we find that the well-being of Europeans would drop by between 7 percent and 15 percent. This estimate should be viewed as a lower bound: going back to national currencies would have many other negative consequences that go beyond the decline in cross-border trade.

To summarise, there is a need for quantitative models of trade and innovation if we want to identify the barriers to firm growth and if we wish to analyse which policies are likely to be more effective in breaking down those barriers. Given the complex interaction between trade and innovation, such models are also useful for analysing the impact of different policies and shocks. The goal of this policy report has been to provide such a framework.

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TECHNICAL APPENDIX

This appendix presents the functional forms used in the model, together with the conditions that solve for the equilibrium. For greater details, see Piguillem and Rubini (2012).

A1 Preferences and technologies

The preferences of the consumer in country i are given by the following utility function, for $i = 1,2$:

$$U_i(\{q_i(\omega,t)\}_{\omega \in \Omega_i(t)}) = \int_0^{\infty} e^{-\rho t} \ln Q_i(t)dt,$$

$$Q_i(t) = \left[\int_{\Omega_i(t)} q_i(\omega,t)^{(\sigma-1)/\sigma} d\omega\right]^{\sigma/(\sigma-1)}$$

where ω is the name of the good consumed, and Ω_i is the set of goods available in country i. $\sigma>1$ is the elasticity of substitution between goods.

Production. Each instant, a continuum of firms produce differentiated goods monopolistically. Profits accrue to domestic consumers. Given productivity level z and labour services n, the production function is

$$y(\omega; z, n) = z^{1/(1-\sigma)} n$$

Innovation. Firms innovate to increase their productivity. We choose a functional form for the innovation cost that guarantees that in equilibrium Gibrat's law emerges (growth rates are independent of size). The innovation cost is in labour units. The cost of increasing productivity by an amount $\dot{z}$ depends on the current productivity level z and is given by

$$c_i(z, \dot{z}) = \frac{\kappa_{Ii} z}{2} \left(\frac{\dot{z}}{z}\right)^2$$

Exporting. A firm can export by incurring a sunk export cost equal to κ_x units of labour. Once a firm becomes an exporter, it remains an exporter until it dies. Exports are subject to iceberg trade costs. Trade depletes a proportion τ_x of the good. So if a consumer consumes an amount q of a good, the exporter must ship an amount $(1+\tau_x)q$.

Entry and exit. There is a large pool of potential entrants that can enter anytime by incurring an entry cost equal to κ_ϵ units of labour. After paying the entry cost, entrants' productivity is $z = 1$. In equilibrium, a measure $M(t)$ of firms enter the economy each period. Firms die with an exogenous probability δ.

We close the model by imposing labour market clearing and trade balance, which determines the equilibrium price level and wages in each country.

A2 Steady-state equilibrium

We identify a monopolistically competitive steady state equilibrium for this economy. We therefore drop the time argument t. Also, we drop the name of the good ω and differentiate goods by their type z denoting the measure of type z goods in the economy $\mu(z)$.

Let w_i be the wage rate in country i. Set $w_i = 1$ as numeraire. The price of good type z is $p(z)$. The equilibrium price before trade costs for an exported good is the same as the price of the same good sold domestically, so we do not introduce notation for the price of an exported good. This price is set by the monopolist to maximise profits subject to the demand for its product. This demand function comes from the consumer maximisation problem:

$$\max \ln Q_i$$

$s.t.$

$$Q_i = \left[\int_1^\infty \sum_{j=1}^{J} q_{ij}(z)^{(\sigma-1)/\sigma} \mu_j(z) dz\right]^{\sigma/(\sigma-1)}$$

$$\sum_{j=1}^{J}\int_{1}^{\infty}(1+\tau_{ij})p_j(z)q_{ij}(z)d\mu_j(z) = w_iL_i+\int_{1}^{\infty}\pi_i(z)d\mu_i(z) + R_i$$

The last line is the budget constraint. $\pi_i(z)$ is profits of a firm z. R_i is tax revenue. τ_{ij} is the iceberg cost to export one unit from country j to i, with $\tau_{ij} = 0$.

Let the right hand side be equal to I_i (for income). The demand for good z is

$$q_{ij}(z) = ((1+\tau_{ij})p_i(z))^{-\sigma}P_i^{\sigma-1}I_i \text{ if } \omega \in \Omega(t)$$

where P_i is the Dixit-Stiglitz aggregate price,

$$P_i = \left[\sum_{j=1}^{J}\int_{1}^{\infty}((1+\tau_{ij})p_i(z))^{1-\sigma}d\mu_i(z)\right]^{1/(1-\sigma)}$$

Firm profit maximisation is done in two steps. The first is a static decision: to choose prices and quantities given the productivity of the firm to maximise variable profits (before innovation or sunk export costs). The second is a dynamic problem that finds the optimal innovation rate and whether to export or not (for non-exporters).

It is straightforward to show that the problem of maximising profits given their productivity results in variable profits are linear in z. Let the variable profits be $\pi_{di}z$ and $\pi_{xi}z$ for non-exporters and exporters in country i.

The dynamic decisions solve the firm value function, given by

$$(\rho+\delta_i)V_{xi}(z) = \max_{\dot{z}}\ \pi_{xi}z - c_i(z,\dot{z}) + V'_{xi}(z)\dot{z}$$

For non-exporters, the dynamic problem consists on when to become exporters and how much to innovate. Their problem is a stopping time problem:

$$V_{di}(z) = \max_{\dot{z}(t),T}\int_{0}^{T}e^{-(\rho+\delta_i)t}\left[\pi_{di}z - c_i(z,\dot{z})\right]dt + e^{-(\rho+\delta_i)T}\left[V_{xi}(z) - \kappa_{xi}\right]$$

New firms enter the economy whenever their expected profits exceed the entry cost. Assuming that new firms never choose to export immediately, the free entry condition is $\kappa_\epsilon = V_{di}(1)$.

A3 Characterising the steady-state equilibrium

The exporter value function is

$$(\rho + \delta_i) V_{xi}(z) = \max_{\dot{z}} \pi_{xi} z - 1/2 k_{Ii} z \left(\frac{\dot{z}}{z}\right)^2 + V_{xi}(z)\dot{z}$$

To solve this problem, we guess and verify that $V_{xi}(z)$ is linear. The solution is the productivity of exporters grows at a constant rate, and is therefore independent of firm size. Thus, Gibrat's law holds. This rate of growth is

$$g_{xi} = \frac{\dot{z}}{z} = (\rho + \delta_i)(1 - \sqrt{1 - h_{xi}}), \quad h_{xi} = \frac{2\pi_{xi}}{(\rho + \delta_i)^{2} \kappa_{Ii}}$$

The rate of growth is increasing in exporter profits and decreasing in innovation costs. The value function in equilibrium is $V_{xi}(z) = \kappa_{Ii} g_{xi} z$.

Firms, while non exporters, solve the following problem

$$(\rho + \delta_i) V_{di}(z) = \max\{\pi_{di} z - \frac{\kappa_{Ii}}{2} g_{di}^2 z + V'_{di}(z) g_{di} z\}, \quad \forall z \in [1, z_{xi}]$$

subject to a value matching condition

$$V_{di}(z_{xi}) = \kappa_{Ii} g_{xi} z_{xi} - \kappa_{xi}$$

and a smooth pasting condition

$$V'_{di}(z_{xi}) = \kappa_{Ii} g_{xi}$$

The optimal growth rate is

$$g_{di} = \frac{V'_{di}(z)}{\kappa_{Ii}}$$

Given this optimal growth rate, the value matching condition implies that the export threshold is

$$z_{xi} = \frac{(\rho + \delta_i)\kappa_x}{(\rho + \delta_i)\kappa_{Ii} g_{xi} - \pi_{di} - (1/2\kappa_{Ii})(\kappa_{Ii} g_{xi})^2}$$

Given this threshold, we can rewrite the solution for the non exporter growth rate by introducing the first order condition into the value function, which yields the differential equation that solves for the optimal non exporter growth rate

$$\frac{g_{di}(z) g'_{di}(z)}{(\rho + \delta_i) g_{di}(z) - (\pi_{di}/\kappa_{Ii}) - (1/2) g^2_{di}(z)} = \frac{1}{z}$$

This differential equation has no explicit solution. This is needed in order to find the distribution of firms. Therefore we approximate the solution by imposing the following functional form

$$g_{di}(z) = (a_i + b_i z^2 + c_i z^3)^{-1}$$

and pin down the parameters by fitting the numerical solution into this functional form. Piguillem and Rubini (2012) show that this fit is surprisingly good.

We next characterise the steady state distribution. Define $\hat{\mu}(t+dt, Z)$ as the measure of firms with productivity z in period t. Define $Z = [z_1, z_2]$ for some $z_2 > z_1$. The law of motion for the measure of productivity is $\hat{\mu}(t+dt, Z) = \int_z \hat{\mu}(t, z - \dot{z}dt) e^{-\delta dt} dz$. That is, the measure of firms with productivity $z \in Z$ is the sum of the incumbent firms that had a productivity $z - \dot{z}dt,\ dt$ periods ago, plus all the firms that were born and in period $t+dt$ had productivity $z \in Z$. This expression can be reduced to $\mu(z) = e^{-\delta dt}$ $\mu(z - \dot{z}dt)$, and then further to $\delta\mu(z) = -\mu'(z)\dot{z}$. For non-exporters, that is $z \in [1, z_{xi}]$, this is $\delta_i \mu_i(z) = -\mu'_i(z) g_{di} z$. This is a first order differential equation, with boundary condition $\mu_i(1) = M_i$. The solution to this equation is $\mu_i(z) = M_i z^{(\delta_i/g_{di})}$. Similarly, for exporters, that is , for $z > z_{xi}, \delta\mu_i(z) = -\mu'_i(z) g_{xi} z$. The boundary condition is $\mu_i(z_{xi})$ $= M_i z_{xi}^{(\delta/g_{di})}$. Thus, the equilibrium distribution in country i is

$$\mu_i(z) = \begin{cases} \exp(\delta_i(b_i(1-z) + c_i/2(1-z^2) + d_i/3(1-z^3)))z^{-a_i\delta_i)}, \\ \text{if } z \leq z_{xi} \;\; A_i z - (\delta_i/g_{xi}), \text{ if } z > z_{xi} \end{cases}$$

where $A_i = z_{xi}^{(\delta_i/g_{xi} - a_i\delta_i)} \exp(\delta_i(b_i(1 - z_{xi}) + c_i/2(1 - z_{xi}^2) + d_i/3(1 - z_{xi}^3)))$.

Notice that the upper tail of this distribution is Pareto (the distribution of exporters) This is Zipf's law.

We can solve for the entire steady state equilibrium as a system of three equations and three unknowns per country. The unknowns are π_d, M, and the wage rate ω. Given these variables, we can identify all the remaining variables in the model. The three equations that pin down these variables are the free entry condition, labour market clearing and trade balance.

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Breaking down the barriers to firm growth in Europe: The fourth EFIGE policy report

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