Internationalization and innovation

SUMMARY

We use a representative and cross-country comparable sample of manufacturing firms (EFIGE) to document patterns of interaction among firm-level internationalization, innovation and productivity across seven European countries (Austria, France, Germany, Hungary, Italy, Spain, United Kingdom). We find strong evidence of positive association among the three firm-level characteristics across countries and sectors. We also find that the positive correlation between internationalization and innovation survives after controlling for productivity, with some evidence of causality running from the latter to the former. Our analysis suggests that export promotion per se is unlikely to lead to sustainable internationalization because internationalization goes beyond export and because, in the medium to long term, internationalization is likely driven by innovation. We recommend coordination and integration of internationalization and innovation policies 'under one roof' at both the national and EU levels, and propose a bigger coordinating role for EU institutions.

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Internationalization and innovation of firms: evidence and policy

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1. INTRODUCTION AND MOTIVATION

Policymakers traditionally have attempted to encourage internationalization based on the implicit rationale that internationalization is associated with productivity growth. Since innovation is the key driver of productivity growth, much attention has been devoted to the specific channels through which trade affects innovation. For example, it is the focus of the OECD's Trade Committee 'Trade and Innovation Project' which aims at 'a better understanding of how exactly trade and investment patterns and policies affect innovation capacity, and interact with other key policies influencing innovation performance' (www.oecd.org/tad/benefitlib/innovation).

The Trade and Innovation Project highlights three channels through which internationalization affects innovation (Kiriyama, 2012): imports, foreign direct investment

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(FDI) and trade in technology as means of technology diffusion; imports, FDI and technology transfer which intensify competition and thus increase incentives to innovate; exports which offer learning opportunities and provide incentives for innovation. All these effects have been interpreted as supporting the case for trade-promoting policies.

These channels originally were investigated in the literature linking trade flows to various macro variables – such as output, income, TFP and innovation – at the aggregate level (see, e.g., Frankel and Romer, 1999). However, as De Loecker (2011) points out, they do not decompose aggregate productivity growth into within-firm productivity gains due to innovation, and between-firm productivity gains due to reallocation. Starting with the study by Bernard and Jensen (1999), a large body of evidence based on micro datasets has emerged, which aims at filling the gap. In his survey of international trade and technology diffusion, Keller (2004) finds little evidence of 'learning by exporting' in econometric studies, while Wagner (2007) finds strong evidence of self-selection of more productive firms into export markets, across a wide range of countries and industries, but little evidence that exporting enhances firm productivity.

There is some support for the 'learning by exporting' channel typically for countries-industries behind the best practice frontier (see, e.g., Van Biesebroeck, 2005; De Loecker, 2007), but few studies show that export fosters innovation (Bratti and Felice, 2012). None support the idea that export promoting policies induce a sufficient level of innovation to foster within-firm productivity growth. In fact, current research into the impact of export on innovation tends rather point to an effect of innovation on exports (Cassiman and Golovko, 2011; Becker and Egger, 2013).

The present paper contributes to this policy debate in three ways. First, we document the pattern of correlations between firm internationalization, innovation and productivity across seven European countries. We rely on the recently released EU-EFIGE/Bruegel-UniCredit (henceforth, EFIGE) dataset. This survey dataset covers a representative and cross-country comparable sample of manufacturing firms across seven European countries (Austria, France, Germany, Hungary, Italy, Spain, the UK) for the year 2008, although several recall questions in the survey concern the previous three years. In relation to internationalization, the dataset allows us to go beyond the basic exporters/non-exporters dichotomy and to distinguish between firms that are internationally inactive firms and various categories of internationally active firms. This is important since international activity is increasingly characterized not only by exports but also by FDI, imports and outsourcing within global value chains. Similarly, in relation to innovation, we go beyond R&D and embrace a broader concept of innovation, which allows us to investigate the role of a richer set of activities, including information technology (IT).

Our analysis emphasizes the role of the number of different internationalization and innovation modes the firm adopts. We refer to the first as 'internationalization intensity' and the second as 'innovation intensity'. We find that larger and more productive firms exhibit higher internationalization intensity and also higher innovation intensity. Our cross-section analysis shows that more innovative country-sector pairs

(which we term 'milieux') number more internationalized firms, while in more internationalized 'milieux' firms are more likely to innovate.

While large and more productive firms are clearly the main drivers of national internationalization and innovation, these activities are not concentrated only in this elite group (the 'happy few'). There is also a fringe of smaller and less productive firms that have a mix of relatively simple international and innovation activities (our data cover numerous small and medium-sized enterprises (SMEs) with 10–250 employees). The most active innovators and exporters are at the top of a pyramidal structure of smaller firms with different levels of internationalization and innovation intensity. The number of these firms increases as the intensity of these activities decreases, while their size and productivity change in the opposite direction.

The second contribution of this paper is an attempt to identify causality in the positive correlation between innovation intensity and internationalization intensity. We are constrained by the cross-sectional nature of our dataset, but exploit the variation across countries and sectors of two exogenous innovation-related variables to instrument innovation intensity. These are: share of firms that have benefited from R&D financial incentives or R&D-related tax allowances, in a given (NACE 2 digits) industry–country pair, during the period 2007–2009; and share of investment in R&D over value added of a given (NACE 2 digits) industry and country in the years 2002–2006. Regressions using these instrumental variables hint at causation running from innovation to internationalization, which is in line with the studies based on micro data.

Our third contribution is to discuss the implications of our findings for trade-promotion and innovation policies for the EU. The most important implication is for the governance of these policies. Currently, innovation policy is the responsibility of DG Enterprise and Industry:

> Innovation policy is about helping companies to perform better and contributing to wider social objectives such as growth, jobs and sustainability. There are many policy tools available to achieve this, ranging from establishing supportive framework conditions (e.g. human resources, an internal market, intellectual property) to facilitating access to finance, policy benchmarking and enabling collaboration or stimulating demand, for instance, through regulation, standards and public procurement. The rationale for European innovation policy is strongest where it is oriented toward addressing the most significant challenges facing society today. The main current European Union's innovation policy is the Innovation Union, Europe 2020 flagship initiative. Its aim is to boost Europe's research and innovation performance by speeding up the process from ideas to markets.[1]

Internationalization policy is not a single responsibility in the EC; trade facilitation is the responsibility of DG Trade and export/import promotion is the responsibility of individual member states with little involvement of EU institutions. The mandate of DG Trade for export/import promotion is rather unclear:

[1] Downloaded from: http://ec.europa.eu/enterprise/policies/innovation/policy/index_en.htm

> The Directorate-General for Trade conducts the EU's common policy on trade with countries beyond the EU borders. This covers, among other things, trade negotiations with countries outside the EU, improving market access for exporters and importers [!], ensuring that fair practices are applied to international trade and assessing the environmental and social impacts of trade. We often receive enquiries that fall outside the scope of our work, such as questions about trade between EU countries, export/import promotion [?], import duties and taxation, consumer protection or recruitment in the European Commission.[2]

Against this background, our findings shed some light on why evidence on the effectiveness of export/import promotion is mixed (see, e.g., Wilkinson and Brouthers, 2006; Lederman *et al.*, 2010). Export promotion on its own is unlikely to lead to sustainable internationalization because internationalization is more than exporting/importing, and because, in the medium to long term, internationalization is likely driven by innovation. In this respect, our analysis suggests that promotion, if any, should be extended beyond exports and imports, to other modes of internationalization such as direct investment, outsourcing agreements and participation as suppliers in global value chains. More crucially, we would recommend that internationalization and innovation policy should be coordinated and integrated within a single responsibility, at both national and EU levels, and that the role of EU institutions should be increased with particular emphasis on innovation policy as a driver of internationalization.

The rest of the paper is organized in four sections. Section 2 presents the dataset and introduces some key definitions of the variables and concepts. Section 3 studies the relation between internationalization and productivity on the one hand, and innovation and productivity on the other, emphasizing the role of internationalization and innovation intensity. Section 4 examines the relation between these intensities more deeply and proposes a causal analysis. Country and sector specific differences are discussed in Section 5 and Section 6 concludes with some policy implications.

2. DATA AND DEFINITIONS

The analysis in this paper exploits EFIGE data, a unique dataset of manufacturing firms in seven European countries. The EFIGE dataset includes 14,759 European firms, including around 3,000 in Germany (DE), France (FR), Italy (IT) and Spain (ES), some 2,200 firms in the UK (UK), and around 500 firms in Austria (AT) and Hungary (HU). Precise figures are reported in Table 1.

The EFIGE dataset has several unique features. First, it is a stratified sample built to be representative of the manufacturing structure of the countries covered. In particular, the sampling design follows a stratification by industry, region and firm size structure. Oversampling of larger firms (>250 employees) is part of the design of the dataset to allow adequate statistical inference for this size class of

[2] Downloaded from: http://ec.europa.eu/trade/contact/

Table 1. Distribution of firms by country and size class

Class size	AT	FR	DE	HU	IT	ES	UK	Total
Employees (10–19)	132	1,001	701	149	1,040	1,036	635	4,694
Employees (20–49)	168	1,150	1,135	176	1,407	1,244	805	6,085
Employees (50–249)	97	608	793	118	429	406	519	2,970
Employees (over 250)	46	214	306	45	145	146	108	1,010
Total	443	2,973	2,935	488	3,021	2,832	2,067	14,759

Source: Authors' elaboration of EFIGE data.

firms; appropriate sample weights then ensure representativeness of the retrieved statistics at country/industry level. Importantly, the survey excludes firms smaller than 10 employees. Imposing this limit means that internationally active firms are likely to be over-represented in our sample compared with the national universe of firms, which typically is characterized by a large number of relatively small, domestic enterprises.[3]

The second feature of the EFIGE dataset is that the data are fully comparable across countries, since it is derived from responses to the same questionnaire, administered over the same time span (January to May 2010).[4]

Finally, the EFIGE survey includes a wide range of questions that allow us to examine more than just balance sheet information to address important issues related to the link between internationalization and innovation. Notably, the survey provides both qualitative and quantitative data on firms' characteristics and activities, for some 150 different variables split into six sections (Proprietary structure of the firm; Structure of the workforce; Investment, Technological innovation and R&D; Internationalization; Finance; Market and pricing). Most of the questions refer to 2008, some ask for information related to 2009 and years previous to 2008, in order to obtain a picture of the effects of the crisis as well as the dynamic evolution of firms' activities.

For the analysis in this paper, EFIGE data were integrated with balance sheet data drawn from the Amadeus database managed by Bureau van Dijk, resulting in nine years of usable balance sheet information for each surveyed firm from 2001 to 2009. These data contribute to the characterization of the firms included in the survey, in particular by enabling calculation of firm-specific measures of productivity. The quality of the Amadeus data varies by country, and not all the variables required to calculate firm-level productivity are reported on all balance sheets. Due to missing variables, EFIGE data matched with firm-level productivity are available for around

[3] See http://www.bruegel.org/datasets/efigedataset for a detailed description of the EFIGE dataset. See also the Appendix for a breakdown of the sample by firm size class and industry.

[4] The questionnaire was administered between January and April 2010 via CATI (Computer Assisted Telephone Interview) or CAWI (Computer Assisted Web Interview) procedures. The complete questionnaire is available on the EFIGE web page, www.efige.org.

half of the firms in the sample. Altomonte *et al.* (2012) provide a detailed discussion of the characteristics of the restricted matched sample and find no major differences with respect to the unrestricted sample or its validation against aggregate statistics except in relation to country representativeness: Italy, France and Spain are the countries with the highest level of firm-level productivity data.

Based on the information contained in the matched EFIGE/Amadeus data, we constructed several variables, reported in following Boxes 1 and 2. Throughout the paper we also use additional definitions and variables. Specifically:[5]

- *Milieux*. In order to control better for sector and country–specific effects and for their potential interaction, we introduce the variable milieu as a country–industry pair. For each pair, we calculate average internationalization and innovation intensities and denote high and low internationalization/innovation intensity milieux by cutting the sample below and above the mean value. This creates four quadrants of possible combinations of high and low internationalization and innovation intensities. For instance, a milieu [Low, High] refers to a country-industry that is below the median for average internationalization intensity and above the median for average innovation intensity.
- *Total Factor Productivity (TFP)*. This is firm-level productivity calculated according to Levinsohn and Petrin's (2003) semi-parametric algorithm (reported in the Appendix).

Box 1 Internationalization variables derived from EFIGE

We define *internationalization intensity* as the number of internationalization modes in which a firm is active simultaneously, from:

1. *Exporter* if the firm has sold abroad, directly from its home country, some or all of its own products/services in 2008 and/or previous years.
2. *Importer* if the firm has purchased at least part of its intermediate goods from abroad in 2008 and previous years.
3. *Outsourcee* if the firm produces in response to receiving an order from another non-domestic firm.
4. *Outsourcer* if the firm's turnover is derived, at least in part, from production activities carried out through contracts and agreements in 2008, or if the firm purchased services from abroad in 2008 or previous years. Unless otherwise specified, *outsourcer* refers to firms involved in *international* outsourcing; it excludes firms involved in domestic outsourcing.

[5] Recall that EFIGE includes 7 countries (Austria, France, Germany, Hungary, Italy, Spain, UK), 19 manufacturing industries, defined by two digit NACE Rev. 1 codes, and 4 size categories of firms based on number of employees: micro (10–19), small (20–49), medium (50–249), large (250+).

5. *FDI maker* if the firm derives at least part of its turnover from production activities abroad based on FDI (foreign affiliates/controlled firms) in 2008, or if the firm acquired (totally or partially) or incorporated other foreign firms between 2007 and 2009 or has at least one foreign affiliate (i.e. the FDI maker holds at least 10% of the foreign affiliate's shares).
6. Based on these five modes, internationalization intensity ranges between 0 and 5.

Box 2 Innovation variables derived from EFIGE

We define *innovation intensity* as the number of modes of innovation in which the firm is active simultaneously. We consider: *innovation outputs*, measured by patents, copyright or design activity; *innovation input*, measured by R&D activity, internal or external; and *Information Technology* (IT) (as in Bloom *et al.* 2012), measured by IT solutions for internal organization, sales and supply chain management.

R&D and patent applications (inputs and outputs) are commonly used indicators of innovation activity. Their advantages and disadvantages are well known (see, e.g., Mohnen and Hall, 2013, for a recent survey). Kleinknecht *et al.* (2002) stress several limitations of R&D as an input measure, two of which are relevant here: R&D is only one of several inputs, and (interpretation of) the definition of R&D is not uncontroversial. They also highlight four disadvantages of patents and patent applications as output measures: they underestimate innovation in low technological opportunity sectors; they overestimate innovative activity among firms that collaborate on R&D; they underestimate the number of small firms that innovate; they overestimate the innovativeness of small-sized firms who are patent holders. While not solving all these problems, in considering external R&D (Almeida and Phene, 2012; Cantwell and Zhang, 2012) and IT solutions (Crespi *et al.*, 2007; Bloom *et al.*, 2012) as additional inputs, and taking industrial design registrations as additional outputs we aim at overcoming some of the constraints imposed by EFIGE data. We prefer not to include product and process innovation as reported by the firm (the EFIGE survey incorporates some of the standard Community Innovation Survey questions on innovation). This is because internationalization often requires minor aesthetic or technical improvements which some firms consider to be product or process innovation, when, according to the OECD Oslo Manual, such adaptations should be classified as product differentiation not product innovation: 'the introduction of minor technical (or aesthetic) modifications in order to reach a new segment of the market, to increase apparent product range or to reposition a product in relation to a competing one' (OECD Oslo Manual, item 170, p. 38).

Since the survey questions refer to a three-year period (averages) not just one year, our innovation modes include:

- Number of IT solutions (0–3):
  1 Internal information management (e.g. SAP/CMS)
  2 Sales IT, e-commerce (online purchasing/online sales)
  3 Supply chain management (of sales/purchase network)
- Number of successful innovations (0–2):
  4 Applied for a patent and/or registered a trade mark
  5 Registered an industrial design
- Number of R&D sources exploited (0–2)
  6 R&D activities carried out in-house
  7 R&D activities acquired from partners

Based on these seven modes, innovation intensity should range from 0 to 7. However, since only 78 firms in our sample are involved in all seven modes, we include firms using 6 and 7 modes in the same group. Hence, our innovation intensity measure ranges between 0 and 6.

3. INTERNATIONALIZATION, INNOVATION AND FIRM PERFORMANCE

In this section we present some stylized facts related to internationalization and innovation that emerge from our data. We examine internationalization and innovation activities, one at a time, linking our findings to the literature on firm heterogeneity. In subsequent sections we explore how they interact.

In the first part of this section, we use our data to replicate key findings in the trade literature: internationalized firms are larger and more productive than non-internationalized firms, and their size and productivity premia follow a stable ranking across internationalization modes. We confirm these findings using both the original EFIGE data and the matched data which allow us to retrieve a measure of TFP.

In the second part of the section we investigate whether the pattern is similar for innovative and non-innovative firms. We find that this is true only to an extent. Whereas internationalized firms are larger and more productive than non-internationalized firms, innovative firms are larger but not necessarily more productive than non-innovative firms. Accordingly, internationalized firms seem to belong to a more select 'club' than innovative firms.

The main contribution of this section is providing a more detailed characterization across a broader set of internationalization and innovation modes than is currently available. We consider the pooled sample of European firms, emphasizing heterogeneity within countries and industries.

3.1. Internationalization and firm performance

Research and policy both focus on the ability to export as a marker of virtuous firm performance. Most studies show that firms that export differ in size and performance from non-exporters, with the former being larger in terms of output and employment and more capital intensive and more productive than non-exporters. This finding, first shown for the US by Bernard and Jensen (1999), has been confirmed for several European countries by Wagner (2007).[6]

However, exporting is only one of several ways that firms may be active in international markets. A relatively recent body of work shows that imports also contribute to explaining company performance. Several contributions suggest the existence of a relationship in which the importing activity of firms leads to within-firm TFP gains. In particular, importing intermediate goods improves plant productivity.[7] There are at least three channels through which imports at firm-level can directly affect a firm TFP: a variety effect, where the broader range of available intermediates contributes to production efficiency; a quality effect, induced by the intermediates available from abroad being of higher quality than those locally available; a learning effect from part of the technology incorporated in the imported goods. However, similar to the case of exporters, importing firms are also *ex-ante* different: they are much bigger, more productive and more capital-intensive than non-importers. Further, both importing and exporting activities are concentrated in a few firms.[8]

Unlike importing, both outsourcing and FDI offer more controlled access to local inputs since these two modes of internationalization allow for greater oversight of the production process. Outsourcing in particular allows the parties to establish a contractual relationship in which some customization of the input can be jointly agreed, and some agreement can be reached on the sharing of profits. However, sharing of profits depends on the implied transaction costs and contractual imperfections being not too overwhelming; if they are too high, the firm may decide on direct investment (paying higher fixed set-up costs) in order to internalize the decision process.[9] Of course, cost saving is not the only firm motivation for going multinational. The decision might be driven by a market-seeking motive since FDI allows them to serve foreign markets locally without incurring the trade costs associated with exporting. In this case the

[6] See also Bernard *et al.* (2012).

[7] See Kasahara and Rodrigue (2008) for Chile, Halpern *et al.* (2009) for Hungary, Amiti and Konings (2007) for Indonesia, Goldberg *et al.* (2010) for India and Kugler and Verhoogen (2012) for Colombia.

[8] See evidence provided by Bernard *et al.* (2007) for the US; Muuls and Pisu (2009) for Belgium; Altomonte and Békés (2010) for Hungary; Kasahara and Lapham (2013) for Chile; Castellani *et al.* (2010) for Italy; Smeets and Warzynski (2013) for Denmark.

[9] The decision on whether to organize production activities within or beyond the boundaries of the firm has been studied theoretically by Antràs and Helpman (2004), and empirically verified by, among others, Nunn and Trefler (2008). See also Helpman *et al.* (2008) for a comprehensive collection of essays on the organization of firms in the global economy.

ensuing multinational structure makes it possible to internalize the foreign sales procedure and retain direct control over the whole process.[10]

Imports, international outsourcing and FDI may also hedge against demand shocks. As Békés *et al.* (2011) show using EFIGE data, during the 2009 recession, firms that were importers or outsourcers or controlled foreign affiliates suffered smaller sales and employment decline than other firms. These modes apparently allowed European firms to spread the pressure along the value chain.

In investigating this range of international activities in our data, at the extensive margin we find that 77% of firms have at least one mode of direct internationalization.[11] Table 2 compares the modes present in our data, showing that exporting is the most frequent, with 67% of firms that can be considered exporters in the three years from 2006 to 2008. More specifically, in 2008, 53% of firms were exporters, while 14% were not exporters but had exported in previous years. Importing is the second most common international activity, with almost half of the firms in our sample importing intermediate goods. For outsourcing activity, 39% of firms acted as suppliers to international customers (outsourcees) and 25% sourced from abroad (outsourcers). FDI is the least frequent activity, and is undertaken only by 10% of the firms in our sample.

For size and performance (proxied here by sales per employee), a clear ranking emerges. Table 2 shows that outsourcers and FDI makers tend to be larger than other

Table 2. Modes of internationalization (descriptive statistics), 2008

	No. of firms	Share of firms (%)	Avg. sales	Avg. No. of employees	Sales per employees
Non-active abroad	3,382	23	5.47	31	0.164
Active abroad	11,377	77	17.92	56	0.238
of which					
Exporters	9,849	67	18.72	58	0.238
Importers	7,298	49	21.66	64	0.249
Outsourcee	5,799	39	19.34	62	0.245
Outsourcer	3,750	25	30.44	78	0.271
FDI maker	1,514	10	59.38	135	0.307
Whole sample	14,759		20.26	64	0.209

Notes: Modes of internationalization are non-mutually exclusive. Sales are in millions of euros and generated from the following turnover range midpoints: 0.5 m, 1.5 m, 6 m, 12.5 m, 32.5 m, 150 m, 500 m.

Source: Authors' elaboration of EFIGE data.

[10] See Helpman (1984).

[11] The high level of internationalization in our sample is also a consequence of the 10 employee threshold. National datasets suggest that very small firms (i.e. with fewer than 10 employees) are unlikely to be engaged in direct trade or foreign investment, although firms can be involved indirectly in international activities – e.g. buying imported tools from a domestic DIY store, selling to a domestic-based wholesaler who later exports the good.

internationally active firms, and outsourcees and exporters tend to be smaller than importers. The ranking is similar for sales per employee.[12]

Existing studies explain these results as being due to 'self-selection'. The paper by Bernard and Jensen (1999) was the first to postulate that the superior performance of exporting firms with respect to purely domestic firms was attributable to self-selection: because of the related fixed (sunk) trade costs, only the most productive firms self-select into export markets.[13] Altomonte and Békés (2010) look at the potential self-selection effect of importers, relating the sunk cost of importing to contract-specific investments and the cost of transferring the embedded technology. Outsourcing production abroad, either at arm's length (identifying and contracting an outsourcee) or setting up (or acquiring and integrating) a new company abroad, also requires substantial *ex-ante* investment (Antràs and Helpman, 2004).

Using data for Germany, Wagner (2011) finds that, compared to firms that do not outsource abroad, those who do are larger and more productive, and have a higher share of exports in total sales. For Japanese firms, Tomiura (2007) finds that firms which are FDI active or are involved in multiple globalization modes are more productive than foreign outsourcers and exporters. Helpman *et al.* (2004) show that FDI is more selective than export for US firms, and explain their finding as due to the higher set-up costs of FDI with respect to export relations. The results for the UK in Criscuolo and Martin (2009) support this explanation.

By nesting the various firm international modes rather than considering them separately, we can build on the measure of *internationalization intensity*, defined in Section 2 as the number of internationalization modes in which a firm is simultaneously involved (Exporter, Importer, FDI maker, Outsourcer, Outsourcee). For frequency, we find a fairly even (18%–22%) split among firms with 0, 1, 2, 3 activities. Firms with 4 international activities are relatively fewer (13%) and just 6% of firms undertake all 5 modes of internationalization. This recalls the 'happy few' notion in Mayer and Ottaviano (2007), that is, that only a very few, very large and very productive firms are deeply integrated in the global economy.

There are two potential explanations for this result. First, the already discussed argument of self-selection: Table 3 shows that the 3% of firms involved simultaneously in five internationalization modes are very much larger (double in size and sales) and around 10% more productive (sales per employee) than firms involved in only four simultaneous international activities. Second, complementarities among the various modes of internationalization may be important. For example, Yasar and Morrison Paul (2007), using data for Ireland and focusing on services imports, argue that there are potential positive effects from international outsourcing, but that these benefits accrue only to firms that are also exporters.

[12] Altomonte *et al.* (2012) show that this ranking is also confirmed for TFP.

[13] Békés and Muraközy (2012) emphasize that these differences are related mostly to sunk cost intensive trade technologies, where firms build long-term relationships.

Table 3. Internationalization intensity and firm characteristics

No. of internationalization activities	No. of firms	Share of firms (%)	Avg. sales	Avg. No. of employees	Sales per employees
0	3,382	23	5.47	31	0.164
1	2,696	18	9.01	35	0.213
2	3,282	22	12.35	45	0.229
3	3,123	21	17.25	57	0.233
4	1,799	12	33.17	87	0.289
5	477	3	76.47	170	0.303

Notes: Sales in millions of euros generated from the following turnover range midpoints: 0.5 m, 1.5 m, 6 m, 12.5 m, 32.5 m, 150 m, 500 m. The variable sales per employee is calculated for a subsample of 7,043 firms using balance sheet data from AMADEUS. No. of internationalization activities is the sum of any of these modes: Exporter, Importer, FDI maker, Outsourcer, Outsourcee.

Source: Authors' elaboration of EFIGE and AMDEUS data.

Figure 1 confirms these results in total factor productivity terms by plotting the TFP distribution for firms with low and high internationalization intensity versus domestic (i.e. non-internationalized) firms. It shows there is a clear ranking for stochastic dominance (tests available on request).[14]

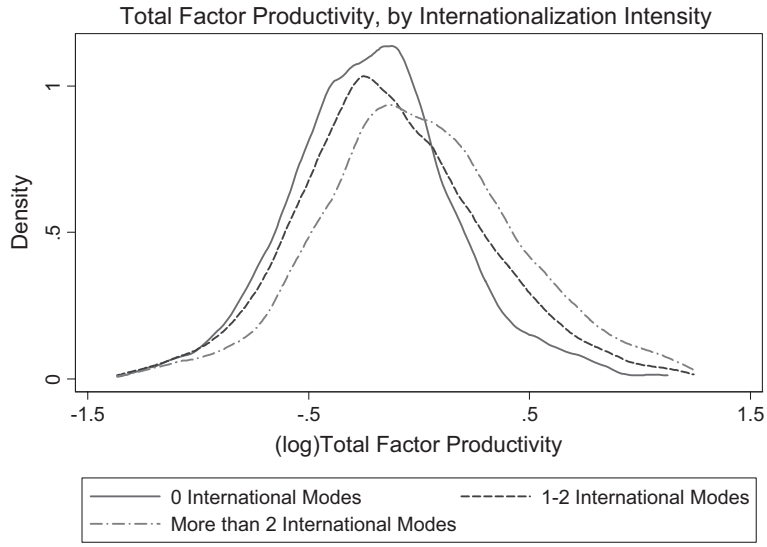

Figure 1. Internationalization intensity and TFP

Note: EFIGE full sample. Results are robust when restricted to Italy, France and Spain, that is, the countries with more than 50% of the firm-level observations for TFP

Source: Authors' elaboration of EFIGE and AMADEUS data.

[14] In our data, internationalization intensity is positively and significantly associated with firms' TFP, controlling for country and industry characteristics as well as firm size (coefficient of 0.02).

3.2. Innovation and firm performance

The richness of the EFIGE data allows us to replicate the internationalization modes analysis for the case of innovation modes, linking the same firm performance to their innovation patterns.

Table 4 replicates the exercise presented in Table 2 for internationalization modes, but applying it to innovation modes and their relationship with firm size and sales per employee. In our sample, 87% of firms are involved in some innovation activity, a figure substantially higher than found by most studies of innovation (the most recent CIS found a 52% rate for the EU27 for 2008–10).[15] The main reason for this is that we use a rather broad measure of innovation. For example, R&D using external sources, and application of IT in management are typically excluded in the innovation literature.

Active firms are larger in terms of both sales and employment and also generate a higher number of sales per employee. Using IT management tools is the most frequent activity, followed by supply chain IT tools. Almost half of the firms also report spending on internal R&D whereas activities such as IT process supporting sales, and external R&D, are less frequent. As expected, breakthrough results yielding new patents or designs are rare. The more infrequent the activity, the larger (in terms of both sales and employment) the firms involved. However, this pattern does not carry over to sales per employee.

Table 5 presents innovation intensity as defined in Section 2 as the number of innovation modes in which the firm is simultaneously involved. The innovation intensity

Table 4. Modes of innovation (descriptive statistics), 2008

	No. of firms	Share of firms (%)	Avg. sales	Avg. No. of employees	Sales per employee
No Innovation	1,919	13	5.80	31	0.169
Innovation	12,840	87	16.00	52	0.226
of which					
IT management	8,208	56	19.99	59	0.239
IT supply chain	6,968	47	18.43	56	0.225
R&D internal	7,015	48	20.55	64	0.232
IT sales	3,441	23	21.05	62	0.238
R&D external	1,914	13	26.89	72	0.253
IN patent	2,286	15	32.49	87	0.221
IN design	1,177	8	31.55	91	0.230
Whole sample	14,759		20.26	64	0.209

Notes: Modes of innovation are non-mutually exclusive. Sales in millions of euros, generated from the following turnover range midpoints: 0.5 m, 1.5 m, 6 m, 12.5 m, 32.5 m, 150 m, 500 m. The variable sales per employee is calculated for a subsample of 7,043 firms using balance sheet data from AMADEUS.

Source: Authors' elaboration of EFIGE data.

[15] See http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Innovation_statistics

variable is constructed in a similar way to the internationalization intensity variable. As shown in Box 2, the maximum number of modes is 7, but since only 78 firms are involved in all modes, we combine firms involved in 6 and 7 modes in the same cell. Table 5 shows that just over half of firms (51.6%) are involved in 1 or 2 modes of innovation; a third (33%) engages in several (3–5) activities: only 2.4% are active in all or almost all modes.[16]

Table 5 shows a clear ranking of firm performance measured as innovation intensity: more innovative firms are not only larger measured by sales and employment, but also are more productive (sales per worker).[17] This differs from the frequency of individual innovation modes in Table 4 where we show that less frequent modes are reserved to larger although not necessarily more productive firms. If we look beyond averages, this inconsistency is less clear cut. Figure 2 compares the TFP distribution of firms with zero, low and high innovation intensity activities. It shows that the distribution of firms involved in more than two innovation modes, measured as TFP, stochastically dominates the TFP distribution of firms involved in less than two innovation modes and the distribution of non-innovative firms.

This differs from the picture for internationalization: firms involved in a larger number of internationalization modes, and firms involved in rarer internationalization modes, are larger and more productive. Figure 1 shows that applies also to stochastic dominance.

Table 5. Innovation intensity and firm characteristics

Number of innovation modes	No. of firms	Share of firms (%)	Avg. sales	Avg. No. of employees	Sales per employee
0	1,919	13.0	5.81	31	0.169
1	3,985	27.0	8.16	36	0.209
2	3,635	24.6	11.62	44	0.225
3	2,615	17.7	19.55	58	0.242
4	1,528	10.4	24.87	70	0.252
5	722	4.9	38.41	98	0.238
6-7	351	2.4	63.41	161	0.260
Whole sample	14,759		20.26	64	0.209

Notes: Modes of innovation are non-mutually exclusive. Sales in millions of euros, and generated from the following turnover range midpoints: 0.5 m, 1.5 m, 6 m, 12.5 m, 32.5 m, 150 m, 500 m. The variable sales per employee is calculated for a subsample of 7,043 firms using balance sheet data from AMADEUS.

Source: Authors' elaboration of EFIGE data.

[16] In a similar vein, the EU Innovation Scorecard (http://ec.europa.eu/enterprise/policies/innovation/files/ius-2013_en.pdf) uses a combined indicator of 24 variables to assess innovation at national level.

[17] Starting from the work of Griliches (1988) on the relationship between innovation investment (R&D) and productivity, a number of studies point to innovation as an important source of productivity differences between firms. A survey of this literature by Hall (2011) finds a substantial positive impact of product innovation on revenue productivity, with a more ambiguous impact of process innovation. In our data, innovation intensity is positively and significantly associated to firms' TFP, controlling for country and industry characteristics as well as firms' size (coefficient of 0.014).

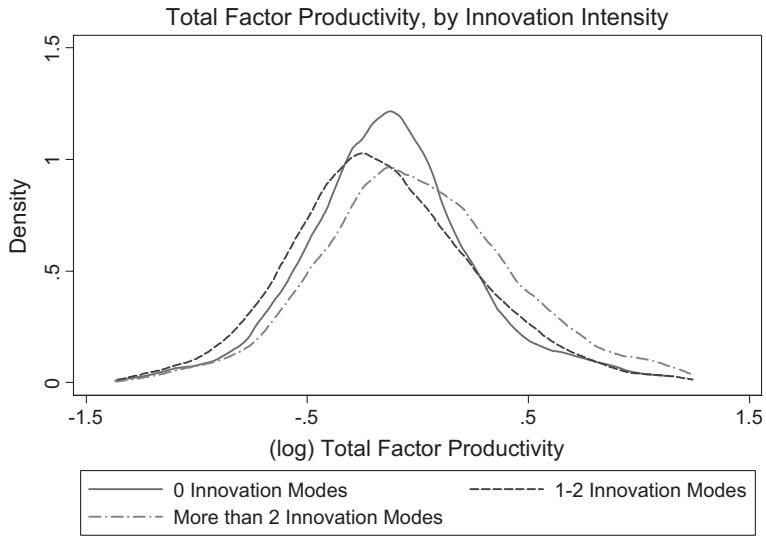

Figure 2. Innovation intensity and TFP

Note: EFIGE full sample. Results are robust when restricted to Italy, France and Spain, that is, the countries with more than 50% of firm-level observations for TFP.

Source: Authors' elaboration of EFIGE and AMADEUS data.

4. INTERNATIONALIZATION AND INNOVATION ACROSS FIRMS

In the previous section, we have investigated the relationship between internationalization and firm performance, and the relations between innovation and firm performance. Existing studies point to several channels of interaction between internationalization and innovation. Let us explore these below.

4.1. Related literature

The most widely studied aspect of the interaction between internationalization and innovation is the link between exports and product and process innovation. There is some evidence that product and (to a lesser extent) process innovation might drive exports at firm level (Becker and Egger, 2013; Cassiman and Golovko, 2011). Evidence supporting the opposite direction of causality (from export to innovation, or 'learning by exporting') is more scant (see Salomon and Shaver, 2005; Damijan and Kostevc, 2010; Bratti and Felice, 2012). From a complementary, but different angle, Desmet *et al.* (2012) show that a reduction in trade costs can stimulate innovation because better access to foreign customers and suppliers may allow firms to become bigger and, thus, better able to bear the fixed costs associated with different innovation modes.[18]

[18] Based on similar logic, Haaland and Kind (2008) discuss the optimality of higher government subsidies for innovation when trade barriers are reduced.

There is a growing consensus, however, that both innovation and exporting are the result of the endogenous choices of firms (Costantini and Melitz, 2008). Therefore, they are inextricably linked and their drivers are *a priori* unclear: firms may conduct innovation activity in anticipation of exports, or may start exporting after successfully innovating. In this latter case, innovation is a type of 'window-dressing', and part of the firm's preparation for embarking on export activity, which gives rise to an observed self-selection effect. This result is confirmed empirically by Van Beveren and Vandenbussche (2010), who find Belgian firms self-select into innovation in anticipation of entry to the export market, rather than that product and process innovation trigger entry to the export market. Aw *et al.* (2011) find that the marginal benefit of both exporting and innovating simultaneously, increases with productivity, with self-selection driving a large part of the complementarity. Similar conclusions are supported by evidence from Canada collected by Lileeva and Trefler (2010), who emphasize that the export-innovation link might run both ways. Bustos (2011) finds supporting evidence for this effect in the case of Argentina and Mercosur.

The most recent literature links innovation not only to exports but also to other internationalization activities. Using data for Argentina, Ottaviano and Volpe Martincus (2011) find that the probability of innovating is increased both by sourcing from abroad and by investment in product improvement. Bøler *et al.* (2012) look at the relationship among R&D investment, innovation and trade in the case of Norwegian firms. They find that among innovating firms or firms investing in R&D, almost all firms import and more innovative firms source more foreign products. Indeed, there is a positive correlation between R&D investment and import share, or the number of imported products and productivity. In addition, firms that start to innovate experience an increase in import share. Amiti and Khandelwal (2013) show that there is a significant relationship between import tariffs and product innovation ('quality upgrading'), whose direction depends on how far the product is from the world quality frontier. For products close to the frontier, low tariffs encourage innovation to upgrade quality; for products far from the frontier low tariffs discourage quality upgrading. In relation to outsourcing, Naghavi and Ottaviano (2010) emphasize incomplete contracts, and posit that outsourced upstream production contributes to the emergence of innovation networks by creating demand for upstream R&D.

Innovation also affects the choice of market entry – by export or FDI. Békés and Muraközy (2012) find that firms who *already* innovate and already sell innovative products compare modes of internationalization based on the relative costs of defending their property rights. If there is a considerable amount of knowledge embedded in the exported product, contractual imperfections shift the balance towards FDI.

In the wake of this growing body of evidence, we investigate the direct relationship between internationalization and innovation. This should contribute to the existing evidence in two respects. First, the unique features of our dataset allow us to provide a richer picture of the relationship between internationalization and innovation

intensities. Second, we propose ways to control for observable and unobservable firm characteristics that might cause spurious correlations between internationalization and innovation.

4.2. Descriptive statistics

The analysis in Section 3 hints at the possible interplay between internationalization and innovation since both are positively associated with firm performance. Basic evidence regarding this interplay is presented in Table 6, where we show that internationalization intensity and innovation intensity are correlated. Moving from top left to the bottom right part of Table 6 (i.e. increasing both number of internationalization modes and number of innovation modes adopted simultaneously) leads to a drop in the number of firms (upper panel), but also to a significant increase in average firm size (lower panel – average employment), in line with the 'happy few' idea. In particular, comparing the top left cell (firms not involved in any innovation or internationalization activity) with the bottom right cell (firms with the highest levels of internationalization and innovation intensity) at the bottom of Table 6, we observe that highly internationalized and innovative firms are of average size (387 employees), which is around 14 times bigger than the average size of non-innovating and non-internationalized firms (28 employees).

Table 6. Internationalization vs innovation intensity

		Innovation intensity							Total No. of firms
		0	1	2	3	4	5	6	
Internationalization intensity	0	757	1,323	718	427	118	29	8	3,380
	1	454	838	689	413	204	78	19	2,695
	2	356	837	940	582	351	167	49	3,282
	3	246	659	801	659	460	197	101	3,123
	4	95	286	420	422	297	170	109	1,799
	5	11	42	67	112	98	81	65	476
Total No. of firms		*1,919*	*3,985*	*3,635*	*2,615*	*1,528*	*722*	*351*	*14,755*

		Innovation intensity							Avg. Empl.
		0	1	2	3	4	5	6	
Internationalization intensity	0	28	33	41	43	71	46	32	42
	1	31	33	44	47	54	52	133	56
	2	36	43	52	69	73	81	79	62
	3	45	54	63	81	91	115	168	88
	4	55	83	86	124	121	175	216	123
	5	120	107	203	152	193	312	387	211
Avg. Empl.		*53*	*59*	*82*	*86*	*101*	*130*	*169*	*97*

Source: Authors' elaboration of EFIGE data.

The evolution of firm size tends to be symmetric across internationalization and innovation intensities. For example, the average size of firms with one innovation activity is 53 employees, with size increasing across the different international activities from 28 (no international intensity) to 120 (maximum international intensity). But also the average size of firms with one international activity is similar (56 employees), with size increasing from 31 employees (for non-innovating firms) to 133 (maximum innovation intensity). Similar patterns emerge if we control for symmetric numbers of innovation or internationalization activities, respectively. Hence, innovation and internationalization seem to be inextricably intertwined with successful firm performance.

Figure 3 translates the information contained in the two panels in Table 6 to two corresponding graphs in order to disentangle the distribution of firms (upper panel A) and their shares (lower panel B) of employment across the innovation and internationalization intensity cells. Both panels exhibit a pyramidal structure, but opposing patterns. In panel A, the peak of the distribution is for lower levels of innovation and internationalization intensities. In panel B, the peak corresponds to high intensities. Most firms appear to engage in very few internationalization or innovation modes, but the bulk of employment is accounted for by firms engaged in several types of internationalization and innovation modes. However, a non-negligible fraction of firms engages simultaneously with some internationalization and innovation modes. Among these, there is some bias towards a larger number of internationalization modes and a lower number of innovation modes.

4.3. Econometric results: baseline

The patterns in Table 6 and Figure 3 are reinforced once we impose more structure on the analysis and estimate simple regressions models. Columns (1), (2) and (3) in Table 7 are obtained by estimating the following equations, respectively:

$$INT_i = \alpha + \beta * INN_i + \varepsilon_i \tag{1}$$

$$INT_i = \alpha + \beta * INN_i + \vartheta_j + \delta_k + \gamma_n + \varepsilon_i \tag{2}$$

$$INT_i = \alpha + \beta * INN_i + \ln(TFP_i) + \vartheta_j + \delta_k + \gamma_n + \varepsilon_i \tag{3}$$

where INT_i represents the internationalization intensity of firm i in year 2008; INN_i is the innovation intensity of firm i in year 2008; β is the coefficient of interest; $\ln(TFP_i)$ is the logarithm of TFP for firm i in year 2008; ϑ_j, δ_k and γ_n are country, sector, and size effects; ε_i is an error term.

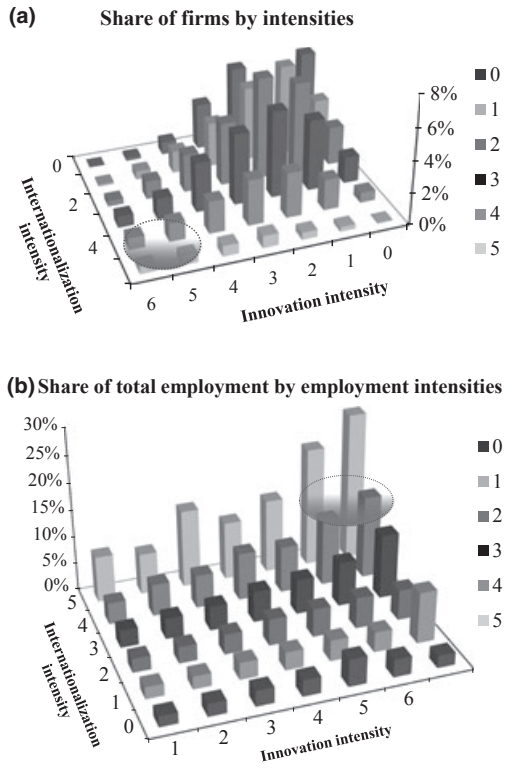

Figure 3. Distributions of firms across innovation and internationalization intensities.

Note: In both panels, the circle denotes the 'happy few'. In panel B, the share of total employment is the sum of firm employment by intensities.

Source: Authors' elaboration of EFIGE and AMADEUS data.

The partial correlation coefficient in Table 7 shows that higher innovation intensity is strongly associated with higher internationalization intensity (Column 1). This holds after adding country, size and sector dummies (Column 2), in order to account for observable (constant) characteristics of firms which might induce both innovation and internationalization. Interestingly, the relationship also holds for the inclusion of firm-level TFP as an additional control, that is, an observable variable that synthesizes a number of firm-level characteristics typically associated with both internationalization and innovation (Column 3).[19] Overall, Table 7 shows that a unit increase in innovation intensity is associated on average with an increase of around 0.3 in internationalization intensity.

[19] EFIGE provides evidence that firms with higher TFP tend, among other things, to have better access to finance and higher levels of human capital, characteristics typically associated with higher probabilities of being innovative or active internationally. See Altomonte *et al.* (2012) for a discussion.

The OLS estimations do not take account of the discreteness of the dependent variable. Hence, as a robustness check, in Table 7 we also report the results of a Multinomial Logit (MLN) where no particular order is given to the non-zero outcomes of the dependent variable (internationalization intensity). The base outcome is zero intensity (non-active abroad).

Table 7. Internationalization and innovation intensity

	Internationalization intensity		
OLS	(1)	(2)	(3)
Innovation intensity	0.360***	0.288***	0.284***
	(0.008)	(0.009)	(0.013)
ln*TFP*			0.207***
			(0.045)
Observations	14,755	14,439	7,129
R^2	0.132	0.254	0.271
Country dummies	No	Yes	Yes
Sector dummies	No	Yes	Yes
Size dummies	No	Yes	Yes

	Internationalization intensity	
Multinomial logit	(4)	(5)
Pr(1)	0.190***	0.190***
	(0.004)	(0.004)
Pr(2)	0.222***	0.223***
	(0.004)	(0.004)
Pr(3)	0.200***	0.200***
	(0.004)	(0.003)
Pr(4)	0.107***	0.106***
	(0.003)	(0.003)
Pr(5)	0.024***	0.024***
	(0.001)	(0.001)
Observations	14,755	14,439
Pseudo-R^2	0.043	0.095
Country dummies	No	Yes
Sector dummies	No	Yes
Size dummies	No	Yes

Notes: * denotes significance at the 10% level, ** 5% level, and *** 1%. Robust standard errors are in parentheses. The dependent variable is internationalization intensity. Country dummies refer to Germany, France, Italy, Spain, UK, Hungary and Austria. Specifications (2), (3) and (5) include NACE 2 digit dummies as well as dummies to control for size. Firm size classes are: 10–19; 20–49; 50–249; more than 250 employees. Pr(1), Pr(2), Pr(3), Pr(4) and Pr(5) are the predicted probabilities (multinomial logit) associated with increasing levels of innovation intensity. All the results reported are obtained using stratification weights. The methodology for calculating TFP is discussed in the Appendix.

Source: Authors' elaboration of EFIGE and AMADEUS data.

Specifically, we estimate two versions (with and without fixed effects) of the following Multinomial Logit (MNL):[20]

$$\Pr(INT_i = j) = \frac{e^{(\alpha+\beta_j * INN_i+\varepsilon_{i,j})}}{1+\sum_{h=1}^{j=5} e^{(\alpha+\beta_h * INN_i+\varepsilon_{i,h})}} \quad (4)$$

where the definitions of the variables are the same as in the OLS regressions. The index j, ranging from 1 to 5, indicates the possible values of the outcome variable. The bottom part of Table 7 shows that the MNL results are in line with the OLS model: being more innovative increases the probability of internationalization, although in a non-monotonic manner (the effect of innovation tends to decrease once the firm is already involved in three or more activities).[21]

We replicated the model specification reported in Column 3 (controlling for TFP) through quantile regressions, in order to check whether the impact of innovation intensity is different for different levels of the variable, that is, whether firms operating in different quantiles of innovation intensity tend also to have higher internationalization intensity. The results (not reported here) are in line with the MNL: the relationship between innovation intensity and internationalization intensity remains positive and significant, but non-monotonic, with the highest effects located around the median quintile (0.33) and higher quantiles of innovation intensity displaying a lower partial correlation (0.26).

The foregoing results support the conclusion that the positive correlation between internationalization and innovation intensities is not spuriously driven by observable firm characteristics, including TFP. This is consistent with the correlation being the outcome of specific firm choices to develop internationalization and innovation jointly (though not necessary sequentially) over time, which is in line with recent studies.

4.4. Econometric results: instrumental variables

We presented results of internationalization intensity as a function of innovation intensity. Although the positive correlation between internationalization and innovation is stable across various specifications and econometric techniques, our results might suffer from a reverse causality problem. As discussed earlier, some

[20] Similar to what we did for the OLS model, we tried to estimate the MNL controlling for TFP. However, the maximum likelihood converges only if we drop either industry or country effects. In both cases, the results (available on request) are in line with the specifications in Table 7.

[21] As a further robustness check for the restrictiveness of the IIA (Independence of Irrelevant Alternatives) assumption in our case, we ran five logit estimations (one for each internationalization mode) where the dependent variables take the value 1 if the firm adopts a particular mode and 0 otherwise. Results are confirmed. Tests are available upon request.

previous studies find that firms innovate as a result of internationalization activities while others find that firms internationalized because of increased innovation intensity.

In principle, the actual causality direction is hard to disentangle, given the cross-sectional nature of our data. However, the cross-country and cross-industry features of the dataset allow us matching the variability across countries and industries of our innovation intensity variable, with other exogenous proxies for innovation that vary along the same dimensions and, which, thus can be used as instruments. In particular we exploit the variation across countries and industries of two exogenous innovation-related variables to instrument innovation intensity:

- *Firms' R&D Incentives* is a variable retrieved from the EFIGE dataset. It is computed as the share of firms that benefited from R&D financial incentives or R&D-related tax allowances in a given (NACE 2 digits) industry–country pair in the period 2007–2009. The variable proxies for the presence of specific R&D promotion policies. It should be correlated with innovation intensity (especially on the input side) while remaining exogenous to internationalization intensity in our sample. Exogeneity can be assumed here as long as the group of firms whose internationalization intensity we measure in the period 2007–2009 does not coincide completely with the group of firms that might have influenced the set-up of R&D promotion policies in a given country-industry before 2007.
- *R&D Intensity* is a variable computed from OECD data. It is measured as the share of investment in R&D over the value added of a given (NACE 2 digits) industry and country for the years 2002–2006. The variable represents a broad proxy for innovation encompassing both inputs and outputs, to the extent that R&D investment in 2002–2006 should be correlated with innovation outputs in 2007–2009 for the same industry–country pairs. Therefore, the variable is retrieved from a different dataset encompassing the entire economic activity for a given industry–country pair. This allows for weak correlation between the instrument and internationalization intensity measured across our sample firms.

Table 8 presents some descriptive statistics of our instrumental variables; the variation across industries and countries is reported in Table A2 in the Appendix.

On average, some 30% of firms in our sample reported to have benefited from some form of R&D incentives (i.e. tax allowances, financial incentives) over the period 2007–2009. However, there is quite large variation across industries and countries. The largest share of firms receiving R&D incentives is in Austria (52%) followed by Spain (46%) and France (40%). The lowest is in Germany (17%). Also, firms enjoying these incentives are more likely to be in high-tech sectors (see Table A2 in the

Table 8. Characteristics of instrumental variables

Descriptive statistics	Observations	Mean	Std. dev.
Firms' R&D incentives	14,746	0.311	0.134
R&D intensity	13,779	3.74	6.47

Pairwise correlations	Innovation intensity	Firms' R&D incentives	R&D intensity
Firms' R&D incentives	0.042***		
R&D intensity	0.157***	0.360***	
International intensity	0.364***	0.143***	0.167***

Note: *denotes significance at the 10% level, ** 5% level, and *** 1%. Robust standard errors are in parentheses.

Source: Authors' elaboration of EFIGE and AMADEUS data.

Appendix for details). Finally, average R&D spending in a given country/industry is around 4% of total value added.[22]

Reassuringly, correlations of the instruments with our dependent variable (internationalization intensity) are low, and smaller than the correlation of the same variable with our endogenous regressor (innovation intensity). At the same time, correlations of the instruments with the endogenous regressor are not high. This is likely to lead to an efficiency loss of the instrumental variable (IV) estimation compared to the OLS.

The regression results with IV are reported in Table 9.[23] In the first stage we regress innovation intensity over the two instruments and find the coefficients both positive and significant (at the 5% level for *Firms' R&D Incentives* and the 10% level for *R&D Intensity*).

In the second stage regression, the coefficient of innovation intensity is also positive and significant (at 1%), with a unit increase in innovation intensity associated here with an almost 1 unit increase in internationalization intensity (0.95). The output of the IV regression shows that the coefficient of innovation intensity is around three times larger than that yielded by OLS (see Table 7); the standard errors are much larger and the *t*-statistic is much lower. These are all signals that by implementing the IV technique we might be incurring a non-negligible efficiency loss due to the use of weak instruments.

Testing formally for the weakness of the instruments, we see that the value of the F statistic for joint significance is not excessively high (lower than the 'safe' rule of thumb value of 10), which confirms our concerns over the correlations.

[22] Note that the variable R&D intensity induces some selection due to the fact that data were not available for some industries in the OECD dataset (the number of data points goes from 14,769 to 13,779). This selection has no effect on the results. More details on the countries and the sectors with missing data are available on request.

[23] Table 9 reports the results obtained using the General Method of Moment (GMM) estimator, but the figures would have been very similar had we used a 2SLS estimator.

Table 9. IV results

First stage regression	Innovation intensity
Firms' R&D incentives	0.379**
	(0.171)
R&D intensity	0.008*
	(0.004)
Country dummies	Yes
Sector dummies	Yes
Size dummies	Yes
Summary statistics	
R^2	0.229
Adj. R^2	0.227
Robust F(2, 13727)	5.267
IV regression	Internationalization intensity
Innovation intensity	0.946***
	(0.348)
Observations	13,760
R^2	0.060
Country dummies	Yes
Sector dummies	Yes
Size dummies	Yes
Test of over-identifying restrictions	
Hansen's J chi^2 (1) = .403196 (p = 0.5254)	

Notes: *denotes significance at the 10% level, ** 5% level, and *** 1% level. Robust standard errors are in parentheses. The dependent variable is internationalization intensity. Country dummies refer to Germany, France, Italy, Spain, UK, Hungary and Austria. Size classes of firms are: 10–19; 20–49; 50–249; more than 250 employees.

Source: Authors' elaboration on EFIGE and AMADEUS data.

However, in the second stage regression the test of over-identifying restriction means we cannot reject the null hypothesis that both instruments are valid (p = 0.5254 > 0.05).[24]

To sum up, our IV results confirm what we showed previously using OLS (i.e. a positive effect of innovation intensity on internationalization intensity) and hint that undertaking innovation efforts might lead to higher internationalization exposure for the firm. However, the econometric tests suggest that we should interpret the precise magnitude of these effects with caution.

[24] If we follow Mikusheva and Poi (2006) and run a conditional IV regression (or Weak IV regression), i.e. recovering values and confidence intervals of the asymptotically correct size, independent of the weakness of the instruments, the *F*-statistic of the first stage is well above the critical threshold of 10. The coefficient of the variable of interest in the second stage is correctly signed and strongly significant, but still larger than that obtained using OLS. Nevertheless, standard errors are much smaller with respect to those for the standard IV. Moreover, both the conditional likelihood ratio and Anderson-Rubin yield confidence sets of [0.947, 1.240] and [0.970, 1.210] are in line with the conventional asymptotic intervals ([0.929, 1.217]). Note that in running the weak IV regression we had to drop industry dummies because of collinearity.

5. INTERNATIONALIZATION AND INNOVATION ACROSS MILIEUX

So far, all the exercises have been carried out on the pooled sample of firms, using dummies to control for possible heterogeneity across countries and industries. In Section 4.2 country and industry dummies explain about 10% and 12% of the variation in internationalization and innovation intensities respectively, which suggests we can expect some, but not an overwhelming variation across countries and industries. However, it is at country and industry levels that policies typically tend to be designed and implemented. Therefore, it might be of some practical interest to look at those levels in greater detail. To do so, we rely on the concept of *milieu* defined in Section 2 as a country–industry pair, and classify every pair relative to (simple) average internationalization and innovation intensities.

The detailed classification is reported in Table A3 of the Appendix. In terms of the innovation intensity index, Hungary has all the worst milieux, for example, wood, textiles and clothing, and furniture industries. Other poor innovation intensity milieux include French wood and fabricated metal industries, Spanish clothing and non-minerals, German leather and Austrian furniture manufacture. Regarding internationalization intensity indexes, the worst milieux are the UK wood industry, Spanish non-minerals and fabricated metals as well as most publishing and food sectors. German leather industry, Italian non-minerals, Spanish wood and Hungarian furniture manufacture are also poor milieux.

The highest innovation intensity milieux are in the UK industries of office and electrical equipment, German machinery and chemicals, Austrian electrical equipment and basic metals, Italian office equipment, and Spanish telecoms manufacture. The highest internationalization intensity is spread across a diverse set of milieux: Austrian textiles and telecoms, French leather, chemicals, telecoms, electrical equipment and furniture, Hungarian vehicles and UK leather industries. There are several milieux with very high innovation and very high internationalization intensities: Austrian and Spanish electrical equipment, German and Italian chemicals, UK leather, telecoms and electrical equipment. At the same time, there is only one case of low intensity in one dimension and high intensity in the other: basic metals in Hungary are highly internationalized, but weak in innovation.

Table 10 compares the share of exporters, importers, FDI makers, and outsourcers, across low and high innovation intensity milieux. It shows that in more innovative milieux the number of internationalized firms is higher. The difference is particularly evident for FDI. Also striking is that more than 75% of firms operating in high innovation intensity milieux are exporters.

Finally, we exploit the information presented in Table A3 to capture the propensity for countries to be involved in innovation and internationalization activities. Figure 4 plots countries' shares of industries with high innovation intensity and share of industries with high internationalization intensity. Figure 4 shows that countries with a larger share of high internationalization intensity industries tend to have a larger share of high

Table 10. International vs innovative milieux

Milieu	Exporter	Importer	FDI maker	Outsourcer
Low innovation intensity	0.60	0.47	0.07	0.24
High innovation intensity	0.75	0.53	0.15	0.27
Difference between high and low innovation intensity	0.15	0.06	0.08	0.03

[a]Figures represent the share of exporters, importers, FDI makers, and outsourcers by low and high innovation intensity milieux (i.e. sector and country pairs) as well as product innovators, process innovators and R&D makers by high and low internationalization milieux.

Source: Authors' elaboration of EFIGE data.

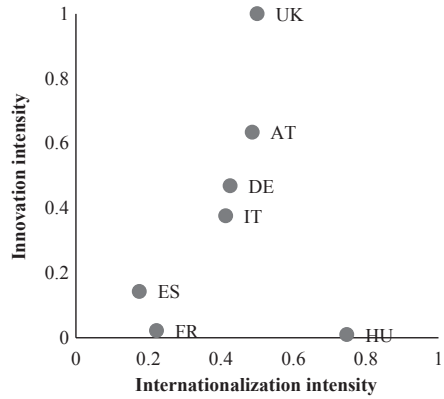

Figure 4. Shares of high intensity industries by country

Source: Authors' elaboration of EFIGE and AMADEUS data.

innovation intensity industries. The outlier is Hungary where a small share of high innovation intensity industries and a large share of high internationalization industries reveal the country's positioning as an active but not innovative part of cross-border value chains. Figure 4 shows also that differences in innovation intensity are larger than differences in internationalization intensity: innovation matters more for driving differences across countries, which is in line with the previously discussed evidence.

Overall, in different countries, different industries exhibit higher internationalization or innovation intensities. Furthermore, the share of high innovation intensity industries seems to vary more across countries than the share of high internationalization intensity industries.

6. CONCLUSIONS AND POLICY IMPLICATIONS

6.1. Summary of findings

We exploited the unique features of the most recent EFIGE dataset to investigate the association between internationalization and innovation, in a representative and

cross-country comparable sample of manufacturing firms with at least ten employees, across seven European countries (Austria, France, Germany, Hungary, Italy, Spain, UK) for the year 2008.

We found that firms in our data are quite active in both innovation and internationalization: 87% of firms devote resources to R&D projects, IT solutions, or patent/design/trademark registrations, while 77% of our firms are active in international trade, cross-border outsourcing relations, or FDI. For modes of internationalization, there is a clear ranking of associated firm performance: FDI makers show the highest productivity, followed by outsourcers and traders. Innovation differences across modes are less clear cut.

There is a great deal of heterogeneity in the extent of firms' simultaneous involvement in internationalization (measured by number of internationalization modes – *internationalization intensity*) and innovation (measured by number of innovation modes – *innovation intensity*): 40% of firms adopt one or two internationalization modes, 21% adopt three, 12% adopt four, and 3% adopt all five internationalization modes; 51.6% of the firms adopt one or two innovation modes, 17.7% adopt three, 10.4% adopt four, and 7.3% are involved in more than five innovation modes.

Firms with high innovation intensity tend also to show high internationalization intensity. Instrumenting innovation intensity by the share of firms that have benefitted from R&D financial incentives or R&D-related tax allowances in a given (NACE 2 digits) industry–country pair, we find evidence that this positive correlation is causal – from innovation to internationalization.

A positive correlation between innovation and internationalization intensities appears at both firm level and country-industry (*milieu*) level, and at country level when average intensity is calculated disregarding the relative numbers of firms in the different industries. If country average intensities are computed weighting by firm numbers in the various industries, the correlation between innovation and internationalization intensities across countries appears weaker, suggesting that innovation matters more than internationalization for driving differences across countries.

6.2. Policy implications

Our findings suggest that EU trade promotion and innovation policies should be better coordinated to reduce the current paradox of generally uncorrelated policies aimed at mostly correlated outcomes.

As discussed in the introduction, trade promotion is the responsibility of individual member states whose governments are concerned mostly with export promotion – demonstrated by the recent proliferation of national Export Promotion Agencies. However, evidence of the extent to which export promotion is effective for fostering internationalization is mixed. Our analysis suggests that export promotion *per se* is unlikely to lead to sustainable internationalization because internationalization is much more than export. Firms, and especially SMEs, can internationalize if they can

establish themselves in the global innovation and production networks; this does not require them to be exporters – there are several other viable modes of internationalization.

Our findings suggest also that export promotion *per se* is unlikely to lead to sustainable internationalization as long as internationalization is associated with innovation. The main problem, as highlighted in the introduction, is that innovation policy is the responsibility of the EC DG Enterprise and Industry and there is little interaction with DG Trade and the national Export Promotion Agencies.

We would recommend coordination and integration of internationalization and innovation policies under a single responsibility at both national and EU levels, and a stronger coordinating role of EU institutions. This would facilitate the relevant policymakers internalizing the external effects of individual policies. For instance, we showed that R&D incentives can have a positive effect on the probability of internationalization, and uncoordinated institutional actions to promote innovation and internationalization could be ineffective and wasteful and result in 'double subsidization'. Coordination of their actions would allow policymakers also to consider integrated international networks of production and innovation. For example, according to DG Trade, 87% of international sourcing of parts for car manufacture is within the EU. Thus, the EU provides a natural framework for coordinated European internationalization and innovation policymaking by the governments of its member states. Within this framework, apparently disparate policies, such as reducing the barriers to innovation by introducing a one-stop-shop for EU-wide patents, and reducing behind-the-borders obstacles to trade via more flexible customs procedures and better harmonized quality standards, would become part of a coordinated agenda.[25]

Discussion

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This is a fascinating paper that uses a unique cross-sectional micro data set to explore the anatomy of internationalization and innovation among manufacturing firms in seven European countries, in an attempt to establish a causal link between the two and on their joint effect on firm size and productivity.

What is unique to the data is that, in addition to an array of firm characteristics, they provide very detailed information on different modes of innovation and internationalization, allowing the authors to measure the intensity of these activities in terms of the number of modes the firm is involved in. Unfortunately, the data do not provide

[25] Van Pottelsberghe (2010) argues that the absence of a one-stop-shop for EU-wide patents acts as a tax on innovation and poses serious challenges to SMEs in the face of global competition.

any information on the intensive margin of involvement in any of these modes. Perhaps unsurprisingly given the existing literature, the paper shows that internationalization and innovation are positively correlated and that they are positively correlated with both output and productivity, although gradients vary along the internationalization and innovation dimensions.

Possibly the most valuable contribution of thepaperrelates to the authors' analysis of the causal link running from innovation to internationalization. Simple (conditional) OLS regressions of internationalization intensity on innovation intensity (in Table 7) point to a positive correlation between these activities. Given that these correlations hold both in the pooled sample (column 1 of Table 7) and *within* country-industry pairs (column 2 of Table 7), it should be no surprise that these also hold *between* country-industry pairs (which the authorsrefer to as *milieus*) as shown in section 5. The challenge with the OLS regressions, which is well discussed by the authors, is that innovation and internationalization are likely to be simultaneously determined, as well as to be affected by possibly the same unobserved firm characteristics, which are likely to impact both activities as well as, potentially, outcomes. OLS estimates are hence likely to be biased.

Instrumental variable regressions that attempt to circumvent such endogeneity are present in Table 9.The authors use (1) survey-based measures of past usage of R&D incentives by sector-country pairs and (2) external measures of R&D intensity by sector-country pairs to instrument for firm's innovation intensity. It is useful to reflect on the logic of this instrumental variable approach before commenting on the results. A good instrument should clearly identify some source of variation in innovation intensity that is arguably exogenous to internationalization. Promising instruments are either variations in the costs of, or the returns to, innovation, although it is somewhat an act of faith to believe that these instruments are uncorrelated with the costs of, or the returns to, internalization and in general with other determinants of the firm's scale and productivity that can themselves affect engagement into these two activities.

Instrument (1) is likely to be more promising than instrument (2), as it relies on some policy variation. Probably, though, an ideal instrument would rely on the differential *availability* (rather than actual *take-up*) of R&D promotion policies across firms. As I infer that such an instrument does not exist, the authors' solution is to use take-up by country-sector pairs, under the implicit assumption that group take-up reflects more closely availability and is less likely to be endogenous to specific firms' choices than individual firms' take-up. One can take issue with these arguments but admittedly a neat source of variation might be hard to find in this context. I cannot but notice though that even sector-country cells take-up is potentially endogenous and that, since the instrument varies by group rather than at the individual level, standard errors of both the first stage and the IV estimates in Table 9 are likely to be underestimated. As estimates are at the margin of statisticalsignificance, a concern is they might not survive group clustering.

Apart from these technicalities, the striking result - and one the authors do not follow up upon - is that the IV estimates in Table 9 are still positive but around three times larger than the OLS estimates in Table 7. What this suggests to me, given that unobserved factors are likely to impact internationalization and innovation similarly, is that internationalization tends to reduce innovation: accounting for reverse causality in fact corrects for a downward bias in the OLS estimates. The story would then be that innovation *fosters* internationalization while internationalization *hampers* innovation. This is possible but slightly hard to maintain given the discussion in the paper. (An alternative interpretation clearly being that firms affected by the instrument react very differently to innovation in terms of their engagement in international activities than the average firm). Perhaps this suggests some degree of caution in interpretingin the IV results.

Based on the result of unintended consequences of innovation policies, whereby these appear to have positive spillovers on firms' internationalization intensity, theauthors call for greater coordination of internationalization and innovation policies. While it is likely that such unintended consequences exist given the empirical analysis, I would be slightly more cautious in supporting this call, at least from a welfare perspective. There is no indication that such spillovers lead to inefficient outcomes as firms appear to fully internalize them.

I conclude by praising the authors. Based on experience, I know how hard it is to characterize complex interrelated phenomena with rich data sets like the one at hand. The authors have opened a window on firms' activities in Europe that other data sets could not shed any light on and they have done that skillfully. The paper is likely to be quite influential in paving the way for additional analyses of the anatomy of firms' behavior and its relationship to policy in Europe.

Panel discussion

Elisabetta Iossa questioned the use of the number of modes as a measure of intensity. Iulia Siedschlag argued that the paper is missing a formal conceptual framework. She also noted that the innovation intensity measure does not distinguish between innovation inputs and outputs. On the basis of the milieu analysis, Nicola Fuchs-Schündeln asked if sectoral policies may actually be appropriate. With reference to Timmer's joint work, Josep Pijoan-Mas wondered why conclusions are being drawn from an analysis of manufacturing industries given this sector's decreasing share in the economies of advanced countries. He enquired if firm-level service sector data could also be acquired. Ester Faia contested that it is not so obvious that the correlation between internationalization and innovation is always positive. In particular, she noted that the US firms which have retreated home are exactly the ones that have been innovating most.

Responding to the comments, Gábor Békés first explained that they initially had the intention of extending their study to a greater number of years and sectors. Békés accepted Faia's remarks but added that the US is predominantly a closed economy whereas the paper is analysing small open economies, though the picture might be different for the EU as a whole. Regarding the intensity measure, Békés stated that each mode is treated as a different endeavour. He also notified the panel that they do not have actual innovation (and internationalization) values given the qualitative nature of the firm surveys. Békés confirmed that firms involved in only small amounts of innovation (on an occasional basis) in more than one mode are unlikely to be included in the sample. Next, Békés stressed that the complexity of their question is so great that it is rather difficult to examine everything within a theoretical model. Nevertheless, he thought that this should be the objective of future research. With regards to innovation inputs versus outputs, Békés noted that a number of robustness checks are provided in the paper. On the issue of causality, he pointed out that the regressions presented in the paper are adopted in order to account for additional controls but that the emphasis is always on associations.

APPENDIX: ADDITIONAL INFORMATION ON DATA CHARACTERISTICS

Productivity estimation

Total factor productivity (TFP) was retrieved from EFIGE and AMADEUS data for around 50% of the sample of firms (balance sheet data from AMADEUS were missing for the remaining firms). As discussed in the text, the resulting restricted sample is unbiased with respect to the main variables of interest (internationalization and innovation) but biased in terms of country representativeness, with Italy, France and Spain being over-represented.

To calculate TFP, we assigned our observational units to sectors (NACE 2 digit levels) pooling firm-level data across countries and years. For each sector we run Levinsohn and Petrin's (2003) semi-parametric production function estimation algorithm, controlling for country and year fixed-effects. More details of the estimation results and benchmarking against other productivity measures (labour productivity, unit labour costs) for EFIGE data are provided in Altomonte *et al.* (2012).

Output is proxied by added value, deflated using industry-specific (NACE rev. 1.1) price indices obtained from Eurostat (using revenues to ensure full comparability). Labour input is measured as number of employees and capital is proxied by the value of tangible fixed assets deflated using the GDP deflator. Material costs are deflated by average industry-specific PPIs (Producer Price Index) weighted by input–output table coefficients.

Table A1. Distribution of firms by country and industry

Industry	AT	DE	ES	FR	HU	IT	UK	Total No. of firms
Food	32	347	459	212	62	238	147	1,497
Tobacco	1	3	4	1	1	1	1	12
Textiles	8	77	46	118	7	196	52	504
Clothing	5	17	50	55	17	109	42	295
Leather	1	13	47	32	4	115	10	222
Wood	21	103	212	93	17	88	89	623
Paper	10	62	27	83	16	71	47	316
Publishing	34	215	100	148	27	105	208	837
Coke, petroleum	1	4	1	3	1	8	6	24
Chemicals	5	95	121	102	20	108	104	555
Rubber, plastic	22	192	148	226	40	169	122	919
Non-minerals	18	94	163	153	30	167	56	681
Basic metals	13	58	68	68	7	76	54	344
Fabricated metals	70	510	580	839	101	611	301	3,012
Machinery	48	503	305	249	68	381	208	1,762
Office, computer	7	28	6	8	1	9	8	67
Electric eq.	13	106	60	113	18	143	116	569
Telecom eq.	5	56	25	94	9	49	101	339
Equipment, nec	15	192	25	58	6	71	80	447
Motor vehicles	6	41	64	73	11	47	33	275
Other vehicles	2	20	42	16	3	33	21	137
Furniture	5	172	258	16	18	211	258	938
Other	4	27	22	1	4	16	4	78
Total No. of firms	346	2,935	2,833	2,761	488	3,022	2,068	14,453

Table A2. R&D incentives, by country and sector

Industry	AT	DE	ES	FR	HU	IT	UK	Avg. by sector/across countries
Food	0.36	0.15	0.41	0.16	0.50	0.34	0.25	0.31
Textiles	0.25	0.15	0.48	0.49	1.00	0.31	0.25	0.42
Clothing	0.50	0.00	0.46	0.42	0.33	0.19	0.12	0.29
Leather		0.20	0.31	0.40	0.00	0.23	0.25	0.23
Wood	0.29	0.16	0.28	0.28	0.33	0.26	0.12	0.24
Paper	0.75	0.15	0.63	0.23	0.50	0.19	0.10	0.36
Publishing	0.22	0.13	0.39	0.13	0.25	0.21	0.10	0.20
Chemicals	1.00	0.17	0.51	0.53	0.18	0.38	0.38	0.45
Rubber, plastic	0.46	0.11	0.41	0.36	0.09	0.36	0.21	0.29
Non-minerals	0.60	0.15	0.47	0.31	0.50	0.36	0.17	0.37
Basic metals	0.71	0.21	0.52	0.36	0.00	0.40	0.26	0.35
Fabricated metals	0.39	0.16	0.36	0.25	0.24	0.32	0.23	0.28
Machinery	0.66	0.20	0.48	0.46	0.32	0.39	0.34	0.41
Office, computer	0.60	0.18	0.60	0.67		0.57	0.40	0.50
Electric eq.	0.75	0.23	0.62	0.34	0.20	0.46	0.38	0.43
Telecom eq.	0.67	0.28	0.55	0.66	0.67	0.40	0.48	0.53
Equipment, nec	0.77	0.24	0.42	0.77	0.25	0.53	0.44	0.49
Motor vehicles	0.00	0.18	0.60	0.59	0.33	0.39	0.22	0.33
Other vehicles	1.00	0.27	0.63	0.56		0.37	0.47	0.55
Other	0.33	0.13	0.41	0.33	0.25	0.35	0.23	0.29
Avg. by country/ across sectors	0.52	0.17	0.46	0.40	0.33	0.32	0.24	0.34

Table A3. Innovation and internationalization intensities by country and sector

Industry	AT	FR	DE	HU	IT	ES	UK	Simple avg.
Panel A: Innovation intensity by sector/country								
Food	1.9	1.3	1.6	0.9	2.1	1.8	2.8	1.8
Textiles	2.5	1.8	2.3	0.6	2.3	2.0	2.9	2.1
Clothing	2.8	1.3	1.9	0.5	1.9	1.5	2.3	1.8
Leather		1.9	1.8	1.5	2.1	1.7	3.6	2.1
Wood	1.5	1.0	1.6	0.6	1.9	1.6	2.2	1.5
Paper	2.9	1.7	2.2	0.8	2.0	2.0	3.2	2.1
Publishing	2.1	1.3	2.1	1.2	2.0	2.0	2.8	1.9
Chemicals	3.4	2.4	3.3	1.5	2.6	2.6	3.1	2.7
Rubber, plastic	2.5	1.9	2.5	1.0	2.2	2.0	3.1	2.2
Non-minerals	1.8	1.5	2.0	0.7	1.8	1.7	2.8	1.8
Basic metals	3.2	1.4	2.3	0.9	2.1	2.2	2.9	2.1
Fabricated metals	1.9	1.1	1.9	0.8	2.0	1.9	2.5	1.7
Machinery	2.6	2.0	2.4	1.0	2.4	2.3	3.1	2.3
Office, computer	2.7	2.9	3.3	3.0	3.1	2.2	3.6	3.0
Electric eq.	3.2	2.0	3.0	0.8	2.5	2.6	3.6	2.5
Telecom eq.	2.6	2.3	2.8	1.0	2.5	3.0	3.2	2.5
Equipment, nec	3.8	2.7	2.4	1.5	2.9	2.2	3.6	2.7
Motor vehicles	2.5	1.8	2.6	1.9	2.4	2.3	2.7	2.3
Other vehicles	3.0	2.1	2.0	0.7	2.5	1.9	3.9	2.3
Furniture	1.2	2.0	2.4	0.7	2.3	2.0	2.9	1.9
Simple avg.	2.5	1.8	2.3	1.1	2.3	2.1	3.0	2.2
Panel B: Internationalization intensity by sector/country								
Food	1.4	1.4	0.9	1.3	1.6	1.3	1.5	1.3
Textiles	3.1	2.7	2.4	2.7	2.3	2.0	2.1	2.5
Clothing	3.0	2.4	1.9	2.3	2.0	1.7	2.1	2.2
Leather		3.0	1.5	2.8	2.1	2.2	3.0	2.4
Wood	2.1	1.5	1.6	1.8	1.8	1.4	1.0	1.6
Paper	2.3	2.2	2.0	2.1	2.1	2.1	1.9	2.1
Publishing	1.9	1.3	1.1	1.3	1.4	0.9	1.3	1.3
Chemicals	2.8	3.0	2.6	2.2	2.8	2.3	2.4	2.6
Rubber, plastic	2.4	2.5	2.1	2.0	2.3	2.1	2.3	2.2
Non-minerals	2.1	1.8	1.6	1.7	1.4	1.3	1.7	1.6
Basic metals	2.8	2.7	2.0	2.7	2.4	2.2	1.7	2.3
Fabricated metals	2.3	1.8	1.6	2.0	1.6	1.3	1.7	1.8
Machinery	2.8	2.9	2.2	2.0	2.5	2.4	2.4	2.4
Office, computer	1.7	3.0	1.8	-	1.4	1.5	1.9	1.6
Electric eq.	3.2	2.4	2.3	2.5	2.1	2.4	2.6	2.5
Telecom eq.	3.6	2.9	2.4	2.4	2.0	2.3	2.4	2.6
Equipment, nec	2.9	2.9	1.8	2.0	2.2	2.2	2.5	2.3
Motor vehicles	2.5	2.5	2.1	3.1	2.5	2.1	2.2	2.4
Other vehicles	0.5	2.7	2.6	2.3	2.3	1.7	2.1	2.0
Furniture	2.0	3.0	1.9	1.5	2.1	1.7	2.0	2.0
Simple avg.	2.4	2.4	1.9	2.0	2.0	1.9	2.0	2.1

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