Local product space and firm-level churning in exported products

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Abstract

This paper explores the determinants of changes to the range of exports at the firm level with a focus on the role played by the firm's local environment. It extends the model developed by Bernard et al. (2010) to a multi-regional setting to account for localized externalities. The model is tested using French micro-data on mono-regional manufacturing firms covering the period 2002-2007. Our main finding is that the local product space has an impact on exporters' product-market entry and exit decisions. Firms tend to modify their exported product mix to achieve congruence with the core products of the locality. Also, firms receive higher revenue from the export of products that are more related to the core capabilities of the locality.

Keywords: Local Product Space, Product Relatedness, Firm Export Churning, France

JEL code: L25, F14, C49

1 Introduction

Recent empirical evidence suggests high levels of churning in exported products at firm level, and highlights the contribution of these changes to growth of aggregate output. Iacovone and Javorcik (2010) report that in Mexico,

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over the period 1994-2003, export variety creation represented 19% of annual exports of all varieties while export variety destruction accounted for 11%. Bernard et al. (2010) in a study of US manufacturing firms over the period 1987-1997 found that the gross contribution of product churning within firms to aggregate manufacturing output is as large as that of firm entry and exit. These changes in firms' product ranges are also key to understand the dynamics of country level comparative advantage. Hanson et al. (2015) studied 135 industries in 90 countries between 1962 and 2007, and found that 60% of the products that account for the top 5% of a country's absolute-advantage industries in a given year, were not in this 5% two decades earlier. Hence, knowing what determines changes in the range of products that a firm exports and whether these changes show some sort of pattern are important issues, worthy of investigation.

Nevertheless, the economic literature on international trade has overlooked firm level churning in exported products for a long time. The traditional theory of comparative advantage relies on a competition framework in which firms are intrinsically mono-product. This also holds for the new trade theory although it does introduce the notions of product differentiation (Krugman, 1979; Ethier, 1982) and heterogeneous firm efficiency (Melitz, 2003). Hence, in these theoretical models churning in exported products is reduced to the decision to start or to stop exporting. Multi-product exporters have attracted some recent research attention but existing theoretical work explains how economies respond to trade liberalization shocks through within firm adjustment margins (Eckel and Neary, 2010; Mayer et al., 2014, 2016; Lopresti, 2016). Whereas, empirical work focuses on growth in intensive margin or the survival of new products (Poncet and Starosta de Waldemar, 2015; Goya and Zahler, 2017). As a result, the determinants and direction of churning in exported products at firm level is still an issue at stake in this literature.

The aim of this paper is to address this open question empirically, building on the theoretical and empirical findings in three different literature strands: industry dynamics, theory of the firm, and economic geography. The industry dynamics literature proposes some explanations for why firms change the range of products produced (not the range exported). The seminal models in this stream of literature (Jovanovic, 1982; Hopenhayn, 1992; Ericson and Pakes, 1995) are based on the mono-product firm assumption but the extension proposed by Bernard et al. (2010) provides a general equilibrium framework in which firm entry and exit can be distinguished from product market entry and exit[1]. In their extension, firms' product market entry decisions are explained as resulting from evolving firm and firm-product specific factors namely productivity and consumer tastes. While this simple model setting proposes explanations of the key drivers of product churning, it does not perform well for explaining the tendency of firms to produce certain products simultaneously (Bernard et al., 2010).

Whereas the theory of the firm helps to explain this tendency for co-producing certain products. The theory of multi-product firm (Teece, 1982) builds on the resource-based perspective (Penrose, 1959), which states that the firm's production resources can provide a number of different production services. At a given point in time, the firm exploits a particular subset of these services and its product portfolio represents the way it uses these resources. Due to the indivisibility of resources or learning, the firm can have excess resources and it diversifies into related markets when this excess cannot be used more effectively by selling / leasing them (Teece, 1982). Hence, the tendency for firms to produce multiple products is driven by commonalities in their underlying resources or the services enabled by these resources or their "relatedness" more generally.

A number of applied studies investigate this related diversification argument based on different connotations of relatedness and diversification, and motivate considering relatedness as a factor shaping churning in exported products. One strand of this work focuses on diversification of firms into new industries or technologies. For example, following the resource-based view, defining diversification as entry into new industries, and relatedness as belonging of industries to same (sub)classes in standard industry classifications; Chatterjee and Wernerfelt (1991) show that depending on the type of excess resources firms can diversify in the related or unrelated direction. Neffke and Henning (2013) measure skill-relatedness among industries using labor flows, and find that firms are more likely to diversify into skill-related industries. Whereas, Breschi et al. (2003) focus on technology resources and conclude that technology relatedness has an impact on the diversification of innovative activities. Another strand of work considers export diversification at different scales ranging from countries to firms (Hidalgo et al., 2007; Hausmann and Hidalgo, 2011; Boschma et al., 2012; Goya and Zahler, 2017). At the firm level and using Chilean data Goya and Zahler (2017) show that for any given firm a new product line is more likely to survive market competition if it is closely related to the firm's existing products. In other words, they underline the role played by within firm complementarities and commonalities among capabilities to explain churning in exported products.

However, the economic geography literature provides further arguments and evidence that relatedness can operate beyond firm boundaries and motivates considering the local economic structure as a factor shaping firm-level churning in exported products. To illustrate, Poncet and Starosta de Waldemar (2015) focus on product relatedness to the local product space and explore its impact on firms' export performance rather than their product-market entry decisions. Based on data on Chinese manufacturing firms, they show that firms producing goods that are closely related to the goods in which their locality is specialized, enjoy higher levels of export revenues in the next period. Based on data on Turkish manufacturing firms Lo Turco and Maggioni (2016) also show that firms are more likely to introduce new products that are more closely related to both within firm and local product-specific capabilities.

Building on this body of work, in this paper we study the main drivers of churning in exported products at firm level, and try to elucidate the particular role played by the locality via product relatedness. We start with a simple model suited to capturing the essence of the relationship between the characteristics of local product space and the dynamics of firm level product churning, and test the model empirically. The simple model we work with is an extension to the model proposed by Bernard et al. (2010) on multiple product firms and product switching. We extend it to a multi-regional setting and introduce the local dimension via urbanization economies common to all firms in the locality, and demand and export externalities the firms enjoy depending on the degree of relatedness of their products to the products exported by the locality.

Empirically, we base our investigations on a rich dataset on French mono-regional manufacturing firms that export both in 2002 and 2007. We use the density measure proposed by Hidalgo et al. (2007) to quantify product relatedness and investigate two main questions. The former inquires the determinants of decisions about the entry (exit) to (from) product markets, especially the impact of the structure of the local product space on these choices. The latter investigates given that a firm starts exporting new products, whether each has an equal share in terms of revenue generation or the structure of the local product space affects growth in each product-market.

Doing that the study mainly contributes to the literature on multi-product exporters by addressing the open question on determinants of churning in exported products but its findings can be articulated to two broader discussions. The first one refers to whether and how spatial distribution of economic (export) activity affects firms' export behavior. Existing work on this relationship includes mostly empirical papers, addressing export performance in terms of the intensive and extensive margins, or the triggers of export activity (Greenaway and Kneller, 2008; Koenig, 2009; Koenig et al., 2010; Cadot et al., 2013; Poncet and Starosta de Waldemar, 2015). Our findings extends this stream of work by showing that space matters also for export diversification. The second question refers to the sources of regional diversification. Existing evidence highlights a tendency at the country/regional level to move in the product space step-by-step by jumping to related goods (Hidalgo et al., 2007; Hausmann and Hidalgo, 2011; Boschma et al., 2012) yet this is the average behavior, not a rule. Different actors (mono-regional or multi-regional incumbents/export starters) can drive abrupt changes to comparative advantage under different conditions (Boschma et al., 2017; Neffke et al., 2018) and hence micro-dynamics underlying behind these aggregate changes are not straightforward. The findings from the present study add to this work by suggesting that mono-regional incumbents tend to diversify in the direction implied by regional capabilities.

The rest of the paper is organized in four sections. The next section presents the theoretical framework. Afterwards, in Section 3 the data sources, sample selection, and measurement of product relatedness will be explained. In Section 4, the econometric specifications, the estimation results, and robustness and implications of these results will be discussed. The final section offers some conclusions.

2 A Simple Theoretical Framework

Our study exploits the model proposed by Bernard et al. (2010), which considers firm level product-churning at the steady state. In this framework, which we call the BRS framework onwards, firms add-drop products in the steady state due to idiosyncratic shocks to productivity and consumer taste. In what follows we introduce and describe the BRS framework in more detail and show how it can be extended to address the role of local interdependencies in changes in the range of exported products at firm level. The BRS model envisaged through this spatial lens is what allows us to derive the key testable propositions of our empirical analysis.

2.1 The BRS Framework

Bernard et al. (2010) extend existing theories in industrial dynamics by proposing a model that explains how a firm chooses in which product markets it will be active. In former models, this question has been the same as firm entry and exit as these models assume a single-product firm. In the BRS model (Bernard et al., 2010), firms choose to produce an endogenous range of products based on the evolution of the firm and firm-product level characteristics.

The BRS model assumes that firm entry entails a sunk entry cost. Once this cost is incurred, firms observe their initial productivity, which is specific to the firm and common to all of its products, and the consumer taste for each of their products. Consumer taste can be interpreted as the product quality as well as some subjective product characteristics that affect consumers' demand for that product. There is also a fixed production cost for each product. Productivity and consumer tastes are assumed to evolve stochastically over time and to be serially auto-correlated but uncorrelated to each other. Finally, labor is assumed to be the only production factor and in inelastic supply.

Under these assumptions, Bernard et al. (2010) define the *zero-profit consumer taste cut-off* ($\lambda_k^*(\varphi)$), which is the level of consumer taste below which production of product k is not profitable for a firm with productivity φ.

$$\pi_k(\varphi, \lambda_k^*(\varphi)) = \frac{R_k(\rho P_k \varphi \lambda_k^*(\varphi))^{\sigma-1}}{\sigma} - f_{pk} = 0 \tag{1}$$

where $\pi_k(\varphi, \lambda_k)$ is the equilibrium profits that a firm with productivity φ and consumer taste λ_k obtains from a variety of product k. R_k is the aggregate product k revenue, P_k is the price index for product k, σ is the elasticity of substitution across varieties within products. In this framework, σ equals $1/(1-\rho)$ where ρ is a parameter that takes values between 0 and 1 and enters the representative consumer utility function[2].

According to Equation 1 firms with higher productivity (φ) face a lower zero-profit consumer taste cut-off ($\lambda_k^*(\varphi)$). Then, the probability that these firms have a consumer taste for their variety of product k higher than $\lambda_k^*(\varphi)$ is higher. This means that it is more likely that producing product k is profitable for them. As productivity increases the probability of producing a product, more productive firms can expected to have a larger product range.

However, this proposition of the model relies on the assumption that consumer tastes are independent within the firm, and across its products. Bernard et al. (2010) recognize that products might have some common features that are valued by customers in different product markets. Therefore, they suggest demand and production interdependencies across products within each firm as a possible extension of the model. However, these interdependencies are not necessarily confined within firm boundaries.

2.2 The BRS Framework through a Spatial Lens

The BRS framework captures the essence of firms' product selection but it is totally silent on the role of firm interactions and agglomeration economies. To investigate whether spatial factors affect how firms determine their product switching strategies, the BRS framework needs to be extended to a multi-regional setting, and relaxation of the simplifying assumption that there are no spatial inter-dependencies across products and firms. In this paper, we propose to model the simplest spatial inter-dependencies required for a useful data analysis while retaining as many as possible of the simplifying features in the original BRS framework.

In extending the framework to a multi-regional setting, we consider that the profitability of a(n) (exported) product for a given firm has not only a firm and a firm-product component as in the original BRS framework but also a location and a product-location component. In introducing location in the analysis we make the simplifying assumption that firm location is exogenous and fixed over time. Hence, we study only how a firm once it is born can optimize its product mix in a context where the profitability of each product line is determined jointly by firm, firm-product, location and location-product-specific random shocks[3]. Compared to the BRS, our framework is more complex because it includes the impact of the spatial inter-dependencies across firms on the firm's choice.

Formally, we assume that new firms are established randomly in a given location[4]. We follow BRS by assuming that each of those randomly and locally born firms incurs a (common to all locations) sunk entry cost of $f_e > 0$ units of labor in order to observe its intrinsic productivity $\varphi \in [\underline{\varphi}, \bar{\varphi}]$ and its intrinsic product qualities for the characteristics embodied in its blueprint for every product, $\lambda_k \in [\underline{\lambda}, \bar{\lambda}]$.

We then depart from BRS by assuming that agglomeration economies prevail in our economy. Those agglomeration economies take two different forms: urbanization economies, which are available to all firms established in a given locality, and localization economies, which are available only to firms that produce similar or related products in a given locality. In the first case, all firms in a given locality enjoy some level of competitive advantage regardless of their product portfolio. This might stem from a common (transportation) infrastructure, social interactions and institutions facilitating exports, or knowledge externalities in general. In the BRS framework, we model this form of agglomeration economies as a shifter that lowers the fixed cost of production/export for all products in a given locality. Specifically f_{pkl} denotes the fixed cost of production of product k in location l. We assume that f_{pkl} has two distinct components: a product-specific component f_{pk} as in the original BRS model, and a location specific component f_{pl}, which depends only on location characteristics not product characteristics. We then assume that f_{pl} is lower in a more urbanized locality.

The second type of agglomeration economies depends on the specificity of the locality's product space. Basically, we assume that the benefits derived from knowledge externalities, cheaper intermediate goods, common export facilities, or social interactions will be stronger if the products exported from a given region are closely related. This type of agglomeration economies arises from co-location of a specific set of industries and is described in the literature as Marshall-Arrow-Romer (MAR) and Jacobian externalities. Specifically, MAR externalities include knowledge externalities fostered by specialization, labor market pooling, and savings on transportation costs (Glaeser et al., 1992) while Jacobs externalities derive from knowledge complementarities and cross-fertilization opportunities across a diverse spectrum of knowledge (Jacobs, 1969). Frenken et al. (2007) suggest also that diversity can take two different forms, i.e. related or unrelated variety, and argue that related industries have correlated demand shocks and that related variety fosters Jacobs externalities. In contrast to urbanization externalities, in the case of both MAR and Jacobs externalities the benefits the firm can obtain depend on the degree of the firm's similarity to the other firms in its location.

Those agglomeration economies can work through rich and diverse channels and impact the firm's marginal costs on the supply side, and the firm's intrinsic product characteristics (technological or subjective) on the demand side. In our setting, agglomeration economies are introduced via product specific consumer taste distributions (the distribution of λ_k) [5]. More precisely, we assume that the probability of firm i to draw a high consumer taste for a given product k is positively correlated not only to its past draws for that product but also to the past draws of neighboring firms for product k or some other products closely related to product k. In addition, we assume that those agglomeration economies are stronger for products that are exported with comparative advantage from the locality. In other words, where core product refers to products exported with comparative advantage by the locality, local externalities will prevail primarily across the "'core products"' in any given locality.

Recalling from the previous section that consumer taste embraces both the quality and subjective aspects of demand, agglomeration economies can operate on consumer taste via technological complementarities/commonalities affecting quality and/or via subjective consumer preferences. For the first case, one may think of some high quality inputs or production capabilities associated to the locality's core products. Local knowledge spillovers or local labor mobility can foster the quality of goods grounding on the same/complementary inputs or capabilities. In the second case, one may consider firms benefiting from foreign consumers' familiarity with product k originating from location l, and these consumers' willingness to buy product k with this provenance.

Therefore, in our framework and in contrast to the BRS framework, the firm's intrinsic product characteristics are not the only determinant of the (foreign)consumer tastes for its variety of products. Also, the characteristics of the local product space matter because of the prevalence of demand complementarities in exporting activities. Based on these assumptions, the effective consumer taste for a given firm-product is no longer independent of firm location. In other words, two firms that would draw the same intrinsic quality for their varieties of a given product k, might nonetheless face very different effective consumer tastes for those varieties depending on how product k is embedded in the firm's local environment. At one extreme, a firm located in a region where product k or products closely related to product k, are already exported with comparative advantage by many other local firms would benefit from a much higher effective consumer taste than its intrinsic consumer taste. At the other extreme, a firm in a location where product k or products closely related to product k have not previously been exported would be disadvantaged by being unable to rely on existing exporting facilities and knowledge flows, and its effective consumer taste for this product could be lower.

Formally, the assumption that demand complementarities arise across firms producing closely related products in a given locality, can be introduced in the BRS framework by making the λ_ks a combination of two components: a purely random component whose distribution has the same property as the distribution modeled in the original BRS, and a deterministic spatially dependent component, which depends on the congruency of product k to the product space in the locality of the firm (Ω_l).

Overall, taking account of both the generic urbanization economies and the MAR and Jacobian economies, which depend on the product-space of the locality, leads to the introduction of two shifters to equation 2.

$$\pi_k(\varphi, l, \lambda_k^*(\varphi, \Omega_l)) = \frac{R_k(\rho P_k \varphi \lambda_k^*(\varphi, \Omega_l)))^{\sigma-1}}{\sigma} - (f_{pk} + f_{pl}) = 0 \qquad (2)$$

On its own equation 2 cannot fully describe the new steady state in our theoretical section. It also cannot substitute for a full analysis of the transition path towards this new steady state. However, this consideration is beyond the scope of our paper. For the purposes of our empirical investigation, equation 2 aims only at making it clear how the equilibrium profit cut-off condition for any individual firm would be impacted by its local environment under the assumption of location and product-specific complementarities across firms.

From equation 2 we can derive several testable propositions related to both the spatial determinants of firm product churning strategies, and the relationship between those micro-economic determinants and the dynamics of regional (local) competitiveness. In the case of firms' churning strategies, equation 2 has direct implications for both the probability that the firm will switch products and the direction of the portfolio change. More precisely, it can be expected that all else being equal, for a given idiosyncratic productivity, a firm will be able to produce a larger set of products in a more urbanized area because of the fixed production cost advantages available. Also, the firm will be more likely to add new products that are more related to the core products of the locality because of the demand complementarities that prevail across neighboring firms. Finally, all else being equal, the firm will be more likely to drop a product k if this product is less congruent with the core products of the locality. These implications allow us to derive our first testable proposition about the direction of firm level product churning:

Testable proposition 1: For a given idiosyncratic productivity and a given location, firm i is more likely to add (drop) product k to (from) its export portfolio if product k is more (less) congruent with locality l's product space.

The second set of implications from our extended BRS framework are related to firm sales dynamics. Basically, as equilibrium profits for related products are higher in our framework, those products can be expected to be the new paths through which firms grow. From this implication, we can derive a second testable proposition.

Testable proposition 2: Given its location and product-market entry decisions, among the new product-markets that the firm starts to serve, the share of export revenues from product k will be larger the greater the congruency of product k to the local product space.

3 Data, Sample, and Measurement of Product Relatedness

3.1 Data Sources

For the empirical analysis, we combine information from three different sources to build an original data set for the period 2002-2007, comprising French manufacturing exporters, their characteristics, the products they export, and the extent that their products are related to the core competencies of their locality. The first data source is the French Customs Statistical Office, which provided us with information on the quantities and values exported by each firm at product level for each destination. The second source is the French National Institute of Statistics and Economic Analyses (INSEE). Via INSEE we accessed FICUS database, which provides balance sheet and financial information on individual enterprises. Finally, we use the BACI[6] database maintained by CEPII[7] research center. BACI (Gaulier and Zignago, 2010) provides information on values and quantities of bilateral world trade flows at the Harmonized System (HS) 6-digit product disaggregation, for more than 240 countries and 5,039 products since 1994.

We use the first two data sources to determine the sample of firms, their characteristics (such as productivity, location, export revenues, etc.), and products. Whereas CEPII database allows us to quantify the extent that a product is related to the core products in a locality. The next two subsections in the sequel explain the use of these data sources in greater detail.

3.2 Sample Selection

To study firm level churning in exported products during 2002-2007, first we used French Customs data to determine the set of exporters existing in both 2002 and 2007. Then, we used FICUS data to geo-localize these firms. FICUS includes two types of information on firm location: the region where the firm's headquarters is located, and the extent of spatial concentration of the firm's employees. Regarding spatial concentration of employees, it classifies firms into three categories: multi-regional enterprises (not more than 80% of their employees located in the same region), quasi mono-regional enterprises (80% to 100% of their employees located in the same region), mono-regional enterprises (100% of their employees located in the same region). For multi-regional and quasi mono-regional enterprises, FICUS enables us to geo-localize only the headquarters although they may have multiple establishments in different regions. This means that for these firms it is not possible to geo-localize precisely which products are produced and exported at which production site, and thus in which region. Hence, in our analysis we focus on mono-regional exporters and exclude those who changed location between 2002 and 2007. Finally, using FICUS we also identify the firms' principal economic activity. We restrict our sample to exporters whose principal economic activity is manufacturing. Again, we exclude firms that experienced a change in their primary economic activity between 2002 and 2007.

Table 1 summarizes the number of all exporters and their export revenues in 2002 and 2007, and provides the same information for manufacturing firms, mono-regional firms, and mono-regional manufacturing firms. Table 1 shows that the number of all firms that we can trace in both 2002 and 2007 and characterize their location and principal economic activity is around 50 thousand. Firms engaged primarily in manufacturing comprise 43% of these firms and generate 73% of export revenues. Firms established in a single region (which remained in that region) constitute 82% of these firms and account for 41% of export revenues. Table 1 shows also that most manufacturing firms are mono-regional. However, the export revenue generated by mono-regional manufacturing firms is smaller than that generated by multi-regional manufacturing firms.

Table 1: Firms Exporting both in 2002 and 2007: by Primary Economic Activity and Spatial Dispersion

	All Firms	Manufacturing Firms	Monoregional Firms	Monoregional Manuf. Firms
Number of Exporters (count)	49,582	21,172	40,498	17,200
Number of Exporters (in %)	100.0	42.7	81.7	34.7
Export Revenues in 2007 (billion Euros)	282.1	206.9	115.9	69.3
Export Revenues in 2007 (in %)	100.0	73.3	41.1	24.6
Change in Export Revenues 2002-2007 (as % of 2002)	30	29	49	34

Source: French Customs and FICUS.

In the econometric analysis we focus on the sub-sample of mono-regional manufacturing firms that exported continuously between 2002 and 2007. This involves several selection issues. First, this focus does not allow a comprehensive explanation of the micro-dynamics of regional diversification. For instance, the impact of relatedness on firm entry/exit shown in Klepper (2007) and Neffke et al. (2012), is beyond the scope of our study.

Second, multi-regional firms are not the majority of all firms but constitute a large portion of export revenues. By excluding them, we might be underestimating the core-products of any given region. Third, our strict focus on manufacturing firms is motivated by the fact that consumer taste in our theoretical framework could also be interpreted in terms of product quality, and a region-specific component of consumer taste makes more sense for producers than for trader firms. However, firms are engaged in manufacturing to different degrees whereas we made a binary classification, i.e. those firms whose primary economic activity is manufacturing are labeled manufacturing firms. Therefore, the conclusions that can be derived from this sample on diversification behavior will be ambiguous regarding the source of relatedness, i.e. it might be due to complementarities /commonalities arising from purely demand or purely knowledge basis, and skills, etc., or a combination of both.

Given these selection issues, over the five years analyzed Table 1 shows that the aggregate export revenues generated by these firms increased by 34% [8]. However, this aggregate growth is created via the different processes that take place within firms: revenue losses due to dropping some products from the export basket, increase or decrease in export revenues from goods preserved in the export basket, generation of additional export revenues from adding goods to the export basket. Table 2 breaks down our sub-sample of firms by the type of changes to their export basket between 2002 and 2007. We distinguish between firms that both added and dropped products from firms that only added or only dropped products or experienced no change to their export basket over the period.

Table 2: Breakdown of Mono-Regional Manufacturing Firms by Type of Change in the Export Basket from 2002 to 2007

Type of Change	Count	Share (%)
Only Adding	2,096	15.50
Only Dropping	1,671	12.36
Both Adding and Dropping	7,880	58.27
No Change	1,876	13.87
TOTAL	13,523	100

Source: French Customs and FICUS.

According to Table 2, in the period 2002 to 2007, only 14% of mono-regional manufacturing exporters maintained the range of products exported unchanged. Note that during 2002-2007, 15% of mono-regional manufacturing exporters added at least one new product to their export basket while the share of those that dropped at least one existing product from their portfolio was 12%. Finally, more than 58% of mono-regional manufacturing exporters modified their export basket by adding at least one product and dropping at least one product. The econometric analysis presented in this paper tries to explain the determinants of these changes.

3.3 Quantifying Product Relatedness

Product relatedness or proximity[9] can stem from several dimensions since they may require similar or complementary sets of resources, skills, knowledge bases, or institutions. Hidalgo et al. (2007) argue that as a consequence of relatedness, countries with a competitive edge in one good may have or may develop advantage in some other good. Hence, they propose measuring the similarity between two products as the conditional probability of having revealed comparative advantage in one of them given that the country has a comparative advantage in the other. Their measure has been used widely to investigate structural transformation and economic development in a number of countries [10].

In fact, the co-occurrence of two products in a country's export basket (with revealed comparative advantage) could stem from not only overlaps in the underlying production processes such as common production factors, input-output relations, common skills, common knowledge base, etc. but also from overlaps in institutions or social and business networks facilitating the export process. Therefore, here the term relatedness goes beyond mere connotation of similarity in terms of sophistication of goods or production features, and embraces also the material and immaterial settings of the production and export processes.

Country j is said to have a revealed comparative advantage (RCA) in product k at a given point in time if the share of product k in country j's export basket is larger than its share in the worldwide export basket. In other words, having RCA in a good means that the country is a *significant exporter* (Hidalgo and Hausmann, 2009) of that good. Following Balassa (1965), RCA_k^j can be expressed formally as follows:

$$RCA_k^j = \begin{cases} 1 & if \frac{x_k^j}{\sum\limits_k x_k^j} / \frac{\sum\limits_j x_k^j}{\sum\limits_j \sum\limits_k x_k^j} > R^* \\ 0 & otherwise \end{cases} \tag{3}$$

where x_k^j is the value of product k exported by country j, and generally $R^* = 1$. The conditional probability $P(k \mid n)$ that a country has RCA in product k given that it has RCA in product n is given by the ratio of the number of countries with RCA in both products over the number of countries with RCA in only product n. Then, Hidalgo et al. (2007) define relatedness between two products k and n (ϕ_{kn}) as the minimum of these conditional probabilities as expressed below. They explain that taking the minimum adds symmetry to the proximity matrix and avoids the value of the conditional probability being 1 if the country is the sole exporter of the good.

$$\phi_{kn} = min\{P(k \mid n), P(n \mid k)\} \quad (4)$$

To estimate the proximity between each product pair, we calculate ϕ making use of BACI database provided by CEPII. BACI harmonizes importer and exporter information, and it is available with versions 1992, 1996, 2002 and 2007 of the HS classification and is updated annually. In this study, we work with version 1992 of the HS product classification. To compute ϕ_{kn}, we retain only manufacturing products at HS 4-digit[11] and 217 countries[12]. To illustrate our computations, Table 3 reports some bilateral proximity indexes between selected HS-4 digit products. For comparability, we use the same set of products as Poncet and Starosta de Waldemar (2015)[13], and for instance, consistently find that Computers and TVs have a high proximity index while Rice and Cars have a low proximity index.

Table 3: Bilateral Product Proximity For Selected HS-4 Digit Products

Product Name	HS-4 Code*	Rice	T-Shirt	TV	Computer	Cars
Oil	2709	0.13	0.11	0.03	0.08	0.03
Rice	1006		0.22	0.04	0.04	0.04
T-shirt	6109			0.12	0.05	0.03
TV	8528				0.39	0.27
Computer	8471					0.23

*Full names of each HS-4 category are as follows: 2709 - crude oil from petroleum and bituminous minerals; 1006 - rice; 6109 - t-shirts, singlets, tank tops etc, knit or crochet; 8528 - television receivers (incl monitors & proj receivers); 8471 - automatic data process machines, magn reader, etc. computer hardwares; 8703 - motor cars & vehicles for transporting persons.

Source: BACI.

Next, we make use of bilateral product proximity to express the extent to which a product is linked to the local product structure. To do that we use the density measure proposed by Hidalgo et al. (2007), which has been employed in a number of empirical studies (Poncet and Starosta de Waldemar, 2015; Boschma et al., 2012). The density measure focuses on the products exported by the locality with comparative advantage. If a product is proximate to these core products, it is considered densely connected to the local product structure.

Let $Density_k^l$ denote the density of product k in its locality l at a given point in time. Let N be the total number of products, and RCA_n^l a binary variable indicating whether locality l has a revealed comparative advantage in product n, as defined in equation 9. Then, $Density_k^l$ can be defined formally as follows:

$$Density_k^l = \frac{\sum_{n=1,n\neq k}^{N} RCA_n^l \, \phi_{kn}}{\sum_{n=1,n\neq k}^{N} \phi_{kn}} \tag{5}$$

In this analysis, we define the locality at the NUTS[14] - 2 level, i.e. French region level. Since France has a large base of manufacturing exporters, and the spatial scale of our analysis is quite broad, individual exporters represent a small fraction of regional exports, meaning that individual exporters have little influence on the set of core products in a region. Indeed, in only 1.9% of cases do the export revenues of a firm in a given market provide the region with a RCA. However, note that the density variable depends on the region's set of core products (reference set), and the bilateral product proximity. Even if a firm has a non-negligible impact on the reference set, bilateral proximity values are determined exogenously using international trade flows, therefore the reference set does not imply an increase or a decrease in product density [15].

As shown in Table 4, the density of a given product might take different values in different regions since each region has a different set of core products. For instance, Table 4 shows that the congruence of the capabilities required to produce and export computers to core local capabilities is the highest in Rhône Alpes and the lowest in Corse.

Table 4: Summary Statistics for Relatedness of Selected HS-4 Digit Products

Product Name	HS-4 Code	Mean	Min	Max
Oil	2709	0.153	0.038 (Corse)	0.261 (Prov. Alpes Cote d'Azur)
Rice	1006	0.179	0.047 (Corse)	0.278 (Prov. Alpes Cote d'Azur)
T-shirt	6109	0.177	0.057 (Corse)	0.300 (Ile-de-France)
TV	8528	0.169	0.037 (Corse)	0.303 (Rhône Alpes)
Computer	8471	0.160	0.036 (Corse)	0.300 (Rhône Alpes)
Cars	8703	0.160	0.046 (Corse)	0.340 (Rhône Alpes)

Source: BACI.

In the econometric specifications, which are presented in the next section, we use the $Density_k^l$ variable to test the propositions about the effect of product relatedness to the local product space on individual firms' product-market entry/exit decisions, and those firms' relative share of exports in each product-market.

4 Econometric Specifications

Our empirical strategy is to test for the theoretical implications we derived about the extensive and the intensive margins of adjustments to the firms' export portfolios under the assumption that the local product spaces matter. If we consider the extensive margin, testable proposition 1 in the theoretical section stipulates that all else being equal, a firm should be more likely to add (drop) a given product to (from) its export basket if this product is more (less) congruent with the local product space in which the firm is operating. To test this proposition, we make use of two logistic regression models[16]. The first is specified in equation 6 and tests whether the firm will be more likely to diversify into products that are more congruent with the product space in its locality, controlling for the firm's initial product mix and productivity and for spatial disparities in urbanization externalities.

$$y_{ik}^{1a} = \beta_0 + \alpha_{im} + \beta_1 * Productivity_i + \beta_2 * Density_k^l + \beta_3 * RCA_k^l + \delta_l + \epsilon_{ik} \quad (6)$$

We observe the firm's export basket at the beginning and at the end of a five year time window. Provided that product k does not exist in the initial export basket of firm i, the dependent variable (y_{ik}^{1a}) gets the value 1 if product k is exported by firm i at the end of the time window (t), and 0 otherwise. Here, we assume a five-year time window to account for the fact that entering a new product market may involve idea generation, product development, tests and trials, adjustments to production lines, administrative activity related to starting exporting, etc. Also, in earlier studies a five year lag is assumed to allow for these preparatory phases (Boschma and Capone, 2016; Poncet and Starosta de Waldemar, 2015).

On the right hand side of equation 6, β_0 is the constant term while α_{im} represents the effect of the initial product mix m of firm i (in $t-5$). This effect comprises existing resources, skills, knowledge bases, or institutions in the firm, and captures the average relatedness of these products to all potential products that the firm might diversify in[17].

$Productivity_i$ refers to the initial labor productivity of firm i, and is calculated by dividing value added (before taxes) by the average effective number of employees in $t-5$ and expressed in logarithms[18]. β_1 is the coefficient of the productivity variable and is expected to be positive since all else being equal, in our theoretical framework more productive exporters are more able to bear the fixed costs of diversifying.

Our main explanatory variables come next in equation 6. First, $Density_k^l$ denotes the extent that product k is related to the products in which firm i's locality (l) has a comparative advantage in $t-5$. The complete definition of this variable was presented in the previous section. It is introduced in equation 6 after taking the logarithm. β_2 is the coefficient of the density variable, which we expect to have a positive value.

We also introduce RCA_k^l, a dummy variable that controls for products already exported by the region with a comparative advantage in $t-5$ with β_3 the related coefficient. β_3 is expected to be positive since the consumer taste that the firm observes for a product that is already being exported by the locality with comparative advantage be higher in our framework. Finally, in equation 6, δ_l denotes locality fixed effects and captures urbanization economies common to all the firms in locality l regardless of what they produce, and ϵ_{ik} is the error term.

Our second logistic regression model specified in equation 7, is the corollary of the above equation and states that all else being equal, firms will be more likely to drop products that are less congruent with the product space in their locality. Equation 7 differs from Equation 6 only in the definition of the dependent variable. Provided that k is a product exported by firm i in $t-5$, y_{ik}^{1b} takes the value 1 if firm i drops product k at time t, and 0 otherwise. According to our theoretical framework, the coefficients θ_1, θ_2, and θ_3 should now be negative rather than positive as in equation 6.

$$y_{ik}^{1b} = \theta_0 + \alpha_{im} + \theta_1 * Productivity_i + \theta_2 * Density_k^l + \theta_3 * RCA_k^l + \delta_l + \epsilon_{ik} \quad (7)$$

Finally, we study our second testable implication related to the intensive margin of adjustment in firms' export baskets (share of export revenues from new products) by means of equation 8. The theoretical section defines testable proposition 2 as stating that after diversification the firm should grow more in a product-market that is more congruent with the product space in its locality. Hence, in equation 8 the dependent variable (y_{ik}^2) is defined as the ratio of export revenues that firm i obtains from a new product k to its total export revenues from all new products at time t. Since entry implies the existence of a potential that the firm wants to capture, all new markets, i.e. both nominator and denominator, are supposed to grow. Nominator and denominator may grow differently for different firms but their relative growth can be considered independent of firm characteristics because the nominator and denominator are affected by the same characteristics and in the same way[19].

$$y_{ik}^2 = \psi_0 + \alpha_{im} + \psi_1 * Density_k^l + \psi_2 * RCA_k^l + \psi_3 * OTH_{ik} + \psi_4 * Past_{ik} + \epsilon_{ik} \quad (8)$$

In this equation, ψ_0 is the constant variable. α_{im}, $Density_k^l$, and RCA_k^l are defined as above. ψ_1, the coefficient associated to $Density_k^l$, is expected to take a positive value since firms are more likely to enjoy a high level of consumer taste for products that are related to the core products of the locality due to demand inter-dependencies. In turn, this would cause equilibrium profits to be higher for such products, leading the firm to grow more in that product line compared to other products introduced during the same period. Along similar lines, ψ_2, which is the coefficient associated with RCA_k^l, is also expected to be positive.

In equation 8 we introduce two additional explanatory variables to control for differences in market entry mode across firms. First, firms can decide to start exporting product k uniquely, or simultaneously with other new products. Second, firms can differ in the chosen timing of their entry over the five-year time window. Both variations could affect the revenues that can be earned by firm i from a given product k.

To control for the first, we introduce the variable OTH_{ik}, which is defined as the sum of the densities of other new products introduced by the firm during the five year time window. This variable allows us to control for two main mechanisms. First, it controls for the mechanical relationship existing between the number of new products and the average value of y_{ik}^2: the higher the former, the lower will be the latter. Second, it controls for how much the firm can grow in a given product-market depending on which other product-markets it has entered, and the level of coherence of these products with the local product space. The coefficient of the variable ψ_3 is expected to have a negative sign, indicating that the relative growth in k^{th} product market will be lower if the firm enters multiple product-markets that are related strongly to the local product space.

To control for the second, we introduce the variable $Past_{ik}$, which is defined as the time elapsed since firm i introduced new product k. This variable can take the values 1 to 5 over our five year time window. We expect that the earlier the firm enters a product-market, the more time it will have to develop distribution channels and penetrate the market. Hence, ψ_4 is expected to have a positive sign.

Table 5: Summary Statistics for Firm Level Variables

	Observation	Mean	Std. Dev.
Productivity	13,523	0.04	0.03
Age	13,523	20.41	12.41
Group	13,523	0.47	0.50
Market Growth	1241	0.02	0.06

Source: FICUS.

During estimations, we also extended the above specifications by including other firm level controls, i.e. firm age, belonging to a group. Age_i refers to the logarithm of the age of firm i in $t-5$. $Group_i$ is a dummy variable, which takes the value 1 if firm i is affiliated to a foreign or French corporate group at time $t-5$. This binary variable can be considered to assess approximately the impact of organizational ties, which might facilitate the transfer of knowledge (within or across regions), decrease fixed production costs, or affect consumer tastes. $Market\_gr_k$ refers to the average annual growth of the world market for product k in the five years previous to the start of our time window. Table 5 presents summary statistics for firm productivity and some other control variables.

5 Results and Discussion

5.1 Estimation Results

The results of our baseline estimation for the first logistic regression model, i.e. equation 6, are presented in column (a) in Table 6. The $Density_k^l$ and RCA_k^l variables have the expected positive and statistically significant coefficient estimates corroborating our working hypothesis that specialization of the region and the extent of product market relatedness to the region's specialization have an impact on the firm's product-market entry decision. However, although the theory in Section 2 explains that higher firm productivity decreases the zero-profit consumer taste cut-off and increases the likelihood that the firm will enter a given product-market, this model does not provide statistical evidence on such an effect. The estimates in column (b) show that in addition to controlling for productivity, controlling for other firm characteristics such as firm age and group belonging yields the same results as presented in column (a).

We diagnose that this finding is driven by the product-mix controls. These controls were added to the model to account for whether the firm's current exporting activity might be affecting its product-market entry decision since there may be some commonalities or complementarity in terms of resources, skills, knowledge bases, or institutions. The advantage of using a dummy for each product-mix is that it takes account of any observable or unobservable effects that might arise from the initial configuration of the trade basket. However, in practice, the use of product-mix dummies causes omissions of substantial numbers of observations from the estimations and causes bias. In our sample, a large number of exporters (about 37%) have at most one counterpart with the same product-mix, and these exporters are excluded from the estimations since we require at least three observations to properly estimate the effect of each product-mix. When we compare the excluded exporters to those included in the estimations (see Table 7, we find that average labor productivity, average tendency to diversify, and average size of the initial product mix are statistically different between the two samples, and are higher for those exporters excluded from the estimations.

To correct for this, we replace the product mix dummies with two proxies to try to capture the effect of the initial configuration of the trade basket. One of these proxies is Num_Prod_i, which refers to the size of the initial trade basket. It is defined as the logarithm of the number of products that firm i exported in 2002. The other refers to industry dummies, which control

Table 6: Parameter Estimates for the Binary Choice Model of Product-Market Entry Decisions

	(a)	(b)	(c)	(d)
$Productivity_i$	-0.007	-0.007	0,050*	0.044*
	(0.020)	(0.020)	(0.028)	(0.026)
$Density_k^l$	7.032***	7.046***	5.831***	5.840***
	(0.213)	(0.213)	(0.121)	(0.121)
RCA_k^l	0.886***	0.886***	0.814***	0.815***
	(0.022)	(0.023)	(0.013)	(0.013)
Age_i		0.015		0.087***
		(0.016)		(0.017)
$Group_i$		0.040**		0.288***
		(0.021)		(0.022)
$Market\_gr_k$		1.658***		1.530***
		(0.057)		(0.036)
Num_Prod_i			0.563***	0.515***
			(0.013)	(0.014)
$Constant$	2.652***	2.556***	-0.859***	-1.095***
	(0.286)	(0.290)	(0.244)	(0.245)
Observations	10,434,857	10,434,857	16,701,833	16,701,833
Region Dummies	Yes	Yes	Yes	Yes
Product-mix Dummies	Yes	Yes	No	No
Industry Dummies	No	No	Yes	Yes
Tukey's Link Test (hatsq)	0.007	0.001	-0.014	-0.020
p-value	0.223	0.814	0.001	0.000
Hosmer-Lemeshow $\chi^2(8)$	15.15	15.28	9.99	12.68
Prob > χ^2	0.056	0.054	0.266	0.124

Clustered standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Results of the Two-Sample Mean-Comparison Tests

	Group	Obs	Mean	Std. Err.	Pr(T>t)
$Productivity_i$	Excluded	5033	-3.409	0.008	0.000
	Included	8490	-3.465	0.005	
Num_Prod_i	Excluded	5033	15.944	0.204	0.000
	Included	8490	4.411	0.044	
Diversified Firms	Excluded	5033	0.967	0.003	0.000
	Included	8490	0.602	0.005	

for the firm's main industry activity. Column (c) in Table 6 presents the estimation results for this revised version of equation 6. Finally column (d) extends the model in column (c) by controlling for firm age, belonging to a group, and growth in the product market.

Substituting the proxies for the product-mix dummies means omitting some part of the effect of the initial configuration of the trade basket, which is reflected by Tukey's Link Test. On the other hand, the use of proxies increases the number of observations used in the estimation and also improves the goodness of fit as demonstrated by the Hosmer-Lemeshow test statistic. Furthermore, the model including the proxies not only confirms the conclusions of the initial model about the key variables of interest ($Density_k^l$ and RCA_k^l) but also the theoretical reasoning about the role of productivity.

Observation of the coefficient estimates in columns (c) and (d) allows us to conclude that for a given product market, the exporters that enter that product market are those with higher productivity as predicted by the theory. In addition to productivity, firm age is found to be positively related to the probability to add product k to export range, all else being equal. One reason for this positive relationship might be that new-born firms may need time to mature on their core-product before they consider diversifying. Also, affiliation to a group is found to have a positive effect on the probability to enter a new product-market. This binary variable can be considered as a very rough assessment of the impact of organizational ties, which may function as a conveyor of knowledge (within or across regions) and decrease fixed production costs or have an impact on consumer tastes. Finally, product market growth appears to increase the probability to enter the market. Expansion of the product market in the world can allow firms to produce in larger quantities in order to meet the high demand, and to enjoy scale economies, which implies lower production fixed costs.

In the case of the coefficient estimates of $Density_k^l$ our key variable of interest, the results imply that firms tend to enter into product-markets that have more common and complementary capabilities with products in which their locality has RCA. This result is in line with the findings in Lo Turco and Maggioni (2016) for Turkish manufacturing firms that the introduction of new products depends on the availability of product specific competencies in the locality. Recall that the $Density_k^l$ variable is introduced in the regression equation in logarithms; thus, a percentage increase in the density of product k in locality l would lead all else being equal to a 6% increase in the odds of entering that product market for firms located in l (exp(5.840*log(1.01))=1.059). The positive and statistically significant coefficient estimate for RCA_k^l reveals further that the probability that a firm diversifies into products that are already one of the core products of the locality is even higher. Odds of entering a product market for core goods is 126% higher than that for non-core goods (exp(0.815)=2.259). The coefficient estimates for $Density_k^l$ and RCA_k^l taken together suggest that among a locality's core goods the one that is the most strongly linked to other core goods is the most likely to be added to the product range.

While Table 6 helps to explain product-market entry decisions, Table 8 presents the results for the determinants of product-market exit decisions formulated in equation 7. As in the previous table column (a) presents the estimations of the original equation, column (b) extends the specification in (a) by including additional firm-level controls, column (c) re-estimates the specification in (a) replacing the product-mix dummies with proxies, and finally column (d) extends the specification in (c) by adding further firm-level controls. The table shows that product-market exit decisions similar to product-market entry decisions are also shaped by productivity and product relatedness. More precisely, it shows that less productive exporters tend to drop products, and the choice of which product to drop is affected by the extent of local externalities. Products that require very different capabilities to what are already available and abundant in the locality are more likely to be dropped. A percentage increase in the density of product k in locality l leads to a 1.2% decrease in the odds of exiting from that product market for firms located in l all else being equal (exp(-1.255*log(1.01))=0.988). Whereas, the odds of dropping a core good is 38% lower than for a non-core good (exp(-0.480)=0.619). Therefore, firms are more likely to drop products that are not among the locality's core products and are less related to the locality's core goods.

Table 8: Parameter Estimates for the Binary Choice Model of Product-Market Exit Decisions

	(a)	(b)	(c)	(d)
$Productivity_i$	-0.034	-0.038	-0.120***	-0.122***
	(0.035)	(0.034)	(0.033)	(0.032)
$Density_k^l$	-1.588***	-1.638***	-1.257***	-1.255***
	(0.190)	(0.190)	(0.118)	(0.118)
RCA_k^l	-0.599***	-0.594***	-0.482***	-0.480***
	(0.030)	(0.030)	(0.017)	(0.017)
Age_i		-0.032		-0.095***
		(0.026)		(0.019)
$Group_i$		0.215***		-0.096***
		(0.034)		(0.027)
$Market\_gr_k$		-2.124***		-1.238***
		(0.472)		(0.221)
Num_Prod_i			0.156***	0.179***
			(0.017)	(0.018)
$Constant$	-1.387***	-1.419***	-2.805***	-2.586***
	(0.297)	(0.309)	(0.234)	(0.238)
Observations	26,817	26,817	78,969	78,969
Region Dummies	Yes	Yes	Yes	Yes
Product-mix Dummies	Yes	Yes	No	No
Industry Dummies	No	No	Yes	Yes
Tukey's Link Test (hatsq)	-0.022	0.003	-0.263***	-0.218***
p-value	(0.296)	(0.884)	(0.000)	(0.000)
Hosmer-Lemeshow $\chi^2(8)$	12.98	5.90	92.45***	82.26***
Prob > χ^2	(0.112)	(0.659)	(0.000)	(0.000)

Clustered standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

The next set of results is based on Equation 8 and shifts the focus from churning decisions to the share of export revenues for a given product range. Hence, it complements the first set of results by investigating whether related diversification is sustained by related growth, which is also a conclusion that can be derived from the theoretical framework since it predicts higher operating profits for related products. Addressing this issue is essential also to understand consequences of these firm-level choices at the aggregate level for local comparative advantage.

Table 9 column (a) presents the results for equation 8, column (b) presents the results derived from replacing the product-mix dummies with proxies. Both models, despite differences in the goodness-of-fit and number of observations lead to the same conclusions. The positive and statistically significant coefficient estimates for $Density_k^l$ and RCA_k^l confirm the proposition about related growth. Among new product-markets, the growth path is the product that is densely linked to the locality's core products. The growth increases if the product is already a core product of the locality. Inter-firm differences in growth in a new product-market (relative to the firm's other new product-markets) stem not only from differences in coherence of that product with the local product space but depend also on how many other new product-markets the firm has entered, and how these products are related to the local product space (OTH_{ik}). The higher the number of product-markets that are related highly to the local product space, the less the given product-market will grow everything else being equal. Finally, the positive and statistically significant coefficient estimate $Past_{ik}$ tells us that among new-product markets the ones that have a larger share of the export revenues are those that are introduced earlier.

Table 9 columns (c) and (d) present the replicates[20] of estimations in columns (a) and (b) for products that are exported in both 2002 and 2007. These replications base on the assumption that as of 2007, sufficient time has passed since entry, and hence differences in the share of export revenues resulting from differences in product-market entry have vanished. The prediction of the theoretical framework that a firm will enjoy higher operating profits for related products is confirmed also for products that have long been in the range.

The findings in Table 9 can be interpreted as an elaboration of the conclusion of Koenig et al. (2010). Koenig et al. (2010) suggest for the case of French exporters that co-location has a positive impact on export performance. Our analysis opens-up the notion of "'co-location"' and suggests that interdependencies among products (common and complementary capabilities) in a given location foster external economies and cause export revenues to increase in certain directions.

Table 9: Parameter Estimates for the Model Explaining Share of Export Revenues

	New Product-Markets		Continuous Product-Markets	
	(a)	(b)	(c)	(d)
$Density_k^l$	0.681***	0.224***	0.617***	2.265***
	(0.044)	(0.047)	(0.043)	(0.026)
RCA_k^l	0.010	0.026***	0.057***	0.057***
	(0.006)	(0.003)	(0.007)	(0.003)
OTH_{ik}	-0.342***	-0.060***	-0.481***	
	(0.017)	(0.007)	(0.025)	
$AVG - OTH_{ik}$				-3.639***
				(0.024)
$Past_{ik}$	0.023***	0.023***		
	(0.002)	(0.001)		
Num_Prod_i		-0.002***		-0.001***
		(0.000)		(0.000)
$Constant$	0.339***	0.571***	0.508***	0.446***
	(0.030)	(0.059)	(0.041)	(0.012)
Observations	10,567	38,725	11,981	38,510
R-squared	0.470	0.23	0.44	0.57
Product-mix Dummies	Yes	No	Yes	No
Industry Dummies	No	Yes	No	Yes

Clustered standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

5.2 Robustness Checks and Discussion

We check the sensitivity of the findings with respect to two main design features: choice of time window and quantification of relatedness. Concerning the first aspect, we replicate the analysis for the period 1997-2002 to check whether or not the findings are sensitive to the choice of time window. Appendix 1 provides the results of this replication, which show that the conclusions derived from the behavior of French exporters during the 2002-2007window are valid also for the 1997-2002 time window.

Concerning the second aspect, we considered alternative ways of measuring bilateral product proximity and density, checked the differences among them, and studied the behavior of these measures over time. The density variables created by changing the definition of bilateral product proximity and the threshold ($R*$) to define RCA turn out to be highly correlated. Also, we checked the temporal correlation for each of these density variables by calculating their values in 1997, 2002, and 2007. For each density measure we observed that the 1997, 2002, and 2007 vectors are highly correlated, which is in line with the intuition that the alignment of the density vector should not change dramatically in the short run because the ability to identify and exploit potential similarities and complementarities among products should take time. Appendix 2 provides the details of this analysis.

Based on all the results obtained from this study we can deduce two explanations for the behavior of mono-regional French exporters whose primary activity is manufacturing. First, firms adjust their trade baskets such that it becomes more coherent with the region's core capabilities. During this process, the product preference follows the order: 1) core products that share many common capabilities with other core products, 2) non-core products that are highly related to the core capabilities, 3) core-products that have (almost) no common capabilities with other core products. Hence, more firms start serving product markets that either constitute the current comparative advantage of the region, or that are closely related to the current comparative advantage. Second, following diversification firms grow more in core or related product-markets. Hence, at the aggregate (regional) level these two facts would lead to path dependency in changes to aggregate comparative advantage.

Studying firms beginning to export and firms exiting from exporting is beyond the scope of the present study, and our findings do not provide a complete explanation of the micro-dynamics of the evolution of the aggregate comparative advantage. However, it is worth mentioning that the implications of our results are in line with the findings in earlier studies explaining national and regional growth paths (Hausmann and Hidalgo, 2011; Boschma et al., 2013). These studies suggest that new growth paths at the national or regional level depend on current capabilities; hence, the next products that a nation or a region will become competent in are those related to the current products on which national or regional RCA depends. Our analysis sheds some light on the micro-dynamics of this process by showing that mono-regional manufacturing incumbents diversify in the same manner.

6 Conclusion

This paper examined an open question about the determinants and direction of churning in exported products at firm level. First, we employed a recent model proposed by Bernard et al. (2010) on product switching and extended it to a multi-regional setting to study the role played by the locality via product relatedness. We tested its key implications using data on French exporters.

For the cross-section of French exporters we studied, our findings confirm that the local product space matters for firms' product-market entry decisions. Our results show that firms tend to modify their range of exports such that their production and export capabilities become more aligned to the core capabilities of the region. Our results suggest also that once firms alter their range of exports, among all new product export lines they enter in, they enjoy greater export revenues in those that are more related to the core capabilities of the locality.

This study contributes to several research streams. First, it extends empirical work on multi-product exporters that takes account of the interdependencies among products. So far, some evidence has been obtained on the survival of new product lines (Goya and Zahler, 2017) and revenue growth in individual product lines (Poncet and Starosta de Waldemar, 2015). Our paper takes a step back, focuses on which product lines are added or dropped, and offers explanations for how product relatedness (operating beyond firm boundaries) shapes this process. While doing that our ambition remained modest in terms of developing a comprehensive trade theory, but both our discussion and findings motivate further theoretical work that relaxes the mono-product assumption in seminal trade models and allows for interdependencies among products and firms especially through local interactions. Second, this study extends the empirical literature investigating the impact of agglomeration economies on the firm's decision to start exporting and firm-level export performance (Greenaway and Kneller, 2008; Koenig, 2009; Koenig et al., 2010; Cadot et al., 2013; Poncet and Starosta de Waldemar, 2015). Our results suggest that the core capabilities of a locality can shape the firm's export basket, and thus suggest another way (i.e. product churning) through which the spatial distribution of economic (export) activity affects firm export behavior. Third, focusing on firm level product churning, our study complements earlier work on changes in countries'/regions' comparative advantage (Hidalgo et al., 2007; Hausmann and Hidalgo, 2011; Boschma et al., 2012). Recent theoretical and empirical work in this area try to explain the micro-dynamics of the changes at these aggregate scales (Boschma et al., 2017; Neffke et al., 2018), and question which actors (local/non-local, incumbent/new) under which conditions drive related or unrelated diversification since related diversification of regions is a general tendency rather than the rule. Our results suggest that mono-regional incumbents are less likely to drive abrupt changes in the comparative advantage of French regions, and leaves multi-regional incumbents and start-ups as potential sources to be explored.

Considering possible extensions to our work, we would emphasize first the theoretical extensions. One option could be to model the demand and supply side complementarities in a more detailed way such that the linkages between the firm's product mix and the local environment are rationalized. In our current framework, local interactions only act through the fixed cost of production and as a component of deterministic consumer taste. A richer set-up would allow the distributions of the individual ϕ's and λ's to be partly endogeneized. However, modeling these interactions might require to go beyond a general equilibrium setting towards a setting more appropriate for tackling the circular causation mechanisms implied by the existence of complex technological or demand complementarities across firms.

From an empirical perspective, we can point to three further extensions to the current work. First, in our study, relatedness between two products is considered to be exogenous to each locality, meaning that for a given pair of goods for each region (or exporter) the underlying capabilities overlap or complement each other to the same extent. However, as Boschma (2017) argues, depending on their history regions can differ in their ability to discover and exploit these commonalities and complementarities. Hence, the empirical analysis in this paper could be extended by taking account of the spatial variation in product relatedness.

Second, in our analysis "local" refers to the regional level. However, the mechanisms transferring complementary or common capabilities could operate at finer geographical levels, or certain capabilities (infrastructures, institutions) might exist only at higher spatial scales. Hence, the role played by locality at different spatial scales is another issue that could be explored.

Third, our empirical set-up does not discriminate between different plausible sources of agglomeration economies. To better identify the nature of the firm interactions influencing churning decisions, firm-product efficiency indexes could be estimated separately (see the methodology recently proposed by Dhyne et al. (2017)). Separate estimates of firm-product efficiency indexes would allow finer assessment and tracking of how the firm is affected by the co-location of firms exporting specific sets of related products. Along the same lines, it would be interesting to consider a larger sample of firms including both manufacturing and trading firms. This would allow investigation of whether different types of firms (pure manufacturers or pure traders, or hybrid firms) are affected differently by their local product space. Finally, we could look for complementary information on the intermediate inputs to distinguish input quality across firms, and use this differentiation to identify quality driven complementarities from other sources of complementarities.

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Appendix 1

This Appendix replicates the results of the empirical analysis for a different time-window: 1997-2002. Table A1.1 presents the replications of the logistic regression models (for product-market entry and exit); A1.2 presents the replications of the regression explaining the share of export revenues from new products. The results show that our empirical analysis is robust to a different time window.

Table A1.1: Robustness Checks for Models Explaining Product Market Entry and Exit: Change of time window

	Entry		**Exit**	
	(a)	(c)	(a)	(c)
$Productivity_i$	-0.002	0.100***	0.005	-0.143***
	(0.025)	(0.025)	(0.035)	(0.026)
$Density_k^l$	3.433***	3.225***	-0.405***	-0.417***
	(0.186)	(0.111)	(0.165)	(0.114)
RCA_k^l	1.073***	0.900***	-0.720***	-0.557***
	(0.024)	(0.015)	(0.028)	(0.018)
Num_Prod_i		0.626***		0.170***
		(0.015)		(0.016)
$Constant$	-3.488***	-4.409***	0.694***	-2.013***
	(0.263)	(0.231)	(0.252)	(0.227)
Observations	10,422,453	15,562,091	29,303	72,100
Region Dummies	Yes	Yes	Yes	Yes
Product-mix Dummies	Yes	No	Yes	No
Industry Dummies	No	Yes	No	Yes
Tukey's Link Test (hatsq)	-0.050***	-0.019***	-0.043**	-0.208***
p-value	(0.000)	(0.000)	(0.050)	(0.000)
Hosmer-Lemeshow $\chi^2(8)$	29.38	17.49**	28.67***	37.74***
Prob > χ^2	(0.000)	(0.025)	(0.000)	(0.000)

Clustered standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Table A1.2: Robustness Checks for Models Explaining Share of Export Revenues: Change of time window

	New Product-Markets		Continuous Product-Markets	
	(a)	(b)	(c)	(d)
$Density_k^l$	0.674***	0.250***	0.498***	2.227***
	(0.076)	(0.055)	(0.048)	(0.028)
RCA_k^l	-0.000	0.023***	0.040***	0.059***
	(0.007)	(0.004)	(0.006)	(0.003)
OTH_{ik}	-0.392***	-0.068***	-0.394***	
	(0.063)	(0.009)	(0.023)	
$AVG - OTH_{ik}$				-3.852***
				(0,022)
$Past_{ik}$	0.024***	0.019***		
	(0.002)	(0.001)		
Num_Prod_i		-0.002***		-0.001***
		(0.001)		(0.000)
$Constant$	0.588***	0.717***	0.715***	0.480***
	(0.019)	(0.056)	(0.017)	(0.013)
Observations	9,043	30,043	12,759	33,880
R-squared	0.47	0.23	0.43	0.57
Product-mix Dummies	Yes	No	Yes	No
Industry Dummies	No	Yes	No	Yes

Clustered standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

Appendix 2

Alternative Product Relatedness Measures

Since product relatedness or proximity stems from similarities and complementarities in terms of resources, skills, knowledge bases, or institutions, it is not easy to measure relatedness by quantifying these dimensions, assigning them weights, and building a composite indicator. Hence, Hidalgo et al. (2007) propose adopting an output-based approach instead to quantify relatedness. As explained in the paper, they measure the proximity between two products as the conditional probability of having RCA in one of these products given that the country has a comparative advantage in the other. Crucial for this definition is the threshold (R^*) that is used to determine whether or not a country (j) has RCA in product k:

$$RCA_k^j = \begin{cases} 1 & if \frac{x_k^j}{\sum\limits_k x_k^j} / \frac{\sum\limits_j x_k^j}{\sum\limits_j \sum\limits_k x_k^j} > R^* \\ 0 & otherwise \end{cases} \tag{9}$$

where x_k^j is the value of product k exported by country j. The threshold R^* is assumed to be 1 in general practice. In the paper, we implemented the definition of Hidalgo et al. (2007) following this general practice. To distinguish it from the alternative measures we develop below, we call it

ϕ^1_{kn}.

Next, we compute a second bilateral proximity measure ϕ^2_{kn} also defined using the procedure established by Hidalgo et al. (2007) but with a lower threshold of 0.75. By decreasing the threshold, we relax the condition to have an RCA.

Finally, we eliminate the threshold completely by using cosine similarity as an alternative relatedness indicator. Again, we measure product proximity following an output-based view however we do not take account of RCA when studying co-existence of products in country export baskets. Therefore, we define a vector $(\vec{k}_t)$ of size $N \times 1$ for product k such that i^th entry of the vector expresses the share of country i in the world market for product k at time t:

$$\vec{k}_t' = [(\frac{x_{1kt}}{\sum\limits_i x_{ikt}}) \quad (\frac{x_{2kt}}{\sum\limits_i x_{ikt}}) \quad ... \quad (\frac{x_{ikt}}{\sum\limits_i x_{ikt}}) \quad ... \quad (\frac{x_{Nkt}}{\sum\limits_i x_{ikt}})] \tag{10}$$

In some sense, $\vec{k}_t$ summarizes the landscape of exports of product k, with intensities at each country. If products k and n have many common resource or skills requirements, then we would expect similar landscapes for these goods since both products will be exported less by countries lacking these resources and skills and exported more by countries rich in these requirements. Conversely, if the production or export processes of any two products have nothing in common there would be no reason to expect similarity in their export landscapes. Thus, we measure the relatedness of two products by calculating the *cosine* of the angle (θ) between two product vectors:

$$\phi^3_{kn} = \cos\theta = \frac{\vec{k}_t \cdot \vec{n}_t}{\vec{k}_t \ \vec{n}_t} \tag{11}$$

Because the entries of the product vectors are non-negative, $\cos\theta$ takes values in the range $[0, 1]$. If $\cos\theta = 0$, this means that two product vectors are orthogonal to each other. Orthogonal product vectors indicate that these products do not co-occur, and hence are not related. At the other extreme, $\cos\theta = 1$ means that the angle between the product vectors is zero, hence their orientation is the same. Thus, the pattern of occurrence in country export baskets for both products is the same indicating a high level of relatedness. Note that *cosine* of the angle (θ) between two product vectors is the geometric interpretation of the un-centered Pearson correlation coefficient. Therefore, this proximity indicator measures the correlation between two product landscapes

Behavior of Product Proximity Measures Over Time

As explained above, the proximity between products might stem from similarities or complementarities in the underlying resources, skills, knowledge bases, or institutions. In time, innovation and learning could enhance or modify these similarities and complementarities. Hence, bilateral product proximities can be expected to evolve over time but at a very slow pace.

We investigate and compare the behavior over time of the three measures described in the previous section by computing ϕs for four years, i.e. 1997, 1998, 2002, and 2007. This allows us to investigate the behavior of the measures in one-year, five-year, and ten-year time windows. Table A2.1 presents the correlations between bilateral product proximities for each measure in 1997, 1998, 2002, and 2007.

Regardless of the measure used to quantify the proximity between a pair of HS-4 products, we observe that the bilateral proximity values are correlated in time although the strength of the correlations decreases over time. This decrease over time might be due to changes in capabilities, in the ability to combine different capabilities, and/or in reallocation of resources.

Among the three measures, the one that yields the highest correlation in the one-year time window is ϕ^3. Since one year is a short time to expect significant changes in capabilities and their re-combinations, we can state that ϕ^3 is more stable over time compared to the other two measures. This difference stems from the fact that ϕ^1 and ϕ^2 are based on a binary definition of RCA, and hence are sensitive to minor variations in the share of a product in a country basket relative to its share in the world.

Table A2.1: Temporal Correlations for the Three Bilateral Product Proximity Measures

Measure	Year	1997	1998	2002	2007
ϕ^1	1998	0.826	1.000		
	2002	0.727	0.746	1.000	
	2007	0.644	0.652	0.726	1.000
ϕ^2	1998	0.853	1.000		
	2002	0.775	0.794	1.000	
	2007	0.701	0.707	0.767	1.000
ϕ^3	1998	0.960	1.000		
	2002	0.880	0.900	1.000	
	2007	0.765	0.780	0.858	1.000

Impact of the Choice of Bilateral Proximity Measure on Density Measure

In our analysis, $Density_k^l$ indicates the extent that product k is related to the products in which firm i's locality (l) has a competitive advantage. Following Hidalgo et al. (2007), it is defined formally as:

$$Relatedness_k^l = \frac{\sum_{n=1,n\neq k}^{N} RCA_{ln}\,\phi_{kn}}{\sum_{n=1,n\neq k}^{N} \phi_{kn}} \tag{12}$$

Therefore, $Density_k^l$ depends on two factors: the choice of ϕ (i.e. how bilateral product proximity is quantified) and the choice of the threshold $R*$ used to determine whether or not a locality has RCA in a given product. To check the impact of these two factors on $Density_k^l$, we build the variable in four different ways, and to simplify the notation we denote these four variables $DensityA$, $DensityB$, $DensityC$, and $DensityD$:

1. $DensityA$ is defined using ϕ^1 and taking $R* = 1$
2. $DensityB$ is defined using ϕ^2 and taking $R* = 0.75$
3. $DensityC$ is defined using ϕ^3 and taking $R* = 1$
4. $DensityD$ is defined using ϕ^3 and taking $R* = 0.75$

Table A2.2 presents the correlations among these four measures at different points in time. It shows that all four density measures are highly correlated to each other regardless of year. This means that product densities are not highly sensitive to how bilateral product proximity is measured or to the threshold ($R*$).

Table A2.2: Correlations among the Four Density Measures in 1997, 2002, 2007

Year	Measure	A	B	C	D
1997	B	0.991	1.000		
	C	0.978	0.980	1.000	
	D	0.973	0.984	0.996	1.000
2002	B	0.989	1.000		
	C	0.972	0.973	1.000	
	D	0.965	0.978	0.994	1.000
2007	B	0.992	1.000		
	C	0.970	0.973	1.000	
	D	0.967	0.976	0.997	1.000

Finally, Table A2.3 presents correlations over time for each density measure to check the stability of the density measure over time. Unlike the bilateral product proximity measures, we find that each density measure is highly correlated over time meaning that the alignment of the vector defined by product densities does not change considerably in 5 or 10 years, which is in line with the intuition that in the short run relatedness of a product to local capabilities should not change dramatically.

Table A2.3: Temporal Correlations for Four Density Measures

Measure	Year	1997	2002	2007
A	2002	0.938	1.000	
	2007	0.826	0.931	1.000
B	2002	0.940	1.000	
	2007	0.853	0.947	1.000
C	2002	0.946	1.000	
	2007	0.835	0.937	1.000
D	2002	0.943	1.000	
	2007	0.858	0.950	1.000

To conclude, the density variable we use to test a key hypothesis in our econometric analysis is robust to certain changes in its definition. We have shown that changing the definition of bilateral product proximity, and the threshold ($R*$) to define RCA yields highly correlated results. Furthermore, regardless of how density is defined, we observe high temporal correlation meaning that the variable performs well for reflecting the intuition that the embeddedness of products in the local product space should not have a drastically different structure in the short run.

Notes

[1]Other notable attempts to model multi-product firms in a general equilibrium framework include Eckel and Neary (2010) and Mayer et al. (2014). However, in those alternative frameworks the steady state range of firm products remains fixed.

[2]See Bernard et al. (2010) and its online technical appendix for all details.

[3]In reality, the firm location is the result of an optimization strategy in a context of uncertainty and random shocks (e.g. the location preference of the entrepreneur). Also in reality, the firm can decide to relocate if its space-dependent profit opportunities change. In this model, we abstract from this margin of adjustment and force firms to optimize their profits by changing their product mix rather than their location or location mix. Relaxing these restrictions would be an obvious and interesting extension of our work.

[4]Note that this assumption related to the spatial distribution of birth is not central to the phenomenon we study. We could assume that at birth, firms optimize their location despite the effect of some random factors. However, as time passes locational factors will

change from those that influence the firm's original choice. In that case, the firm will have two choices: to change location, or to modify the product-mix. In this work, we assume that in the short-to-medium run relocation is not possible, and hence profits can be optimized only by changing the product-mix.

[5]In the conclusion, as a direction for further research we discuss how agglomeration economies could be integrated more comprehensively in the theory and empirical analysis of firm level churning in exported products.

[6]BACI - Base pour l'Analyse du Commerce International.

[7]CEPII - Centre d'Etudes Prospectives et d'Informations Internationales. Accession date: 01/09/2015.

[8]The total number of mono-regional manufacturing exporters reported in Table 2 is the size of the final sample we work with and is smaller than the number reported in Table 1. The difference stems from the fact that we drop firms for which we do not have reliable data to build our control variables (labor, value added, age, group membership and main industrial activity).

[9]We use the terms product proximity and relatedness interchangeably throughout the manuscript.

[10]See for instance, Hausmann and Klinger (2007) for Chile, Hausmann and Klinger (2007) for South Africa, Usui and Abdon (2010) for the Kyrgyz Republic, Abdon and Felipe (2011) for Sub-Saharan African countries, Bayudan-Dacuycuy (2012) for the Philippines, Poncet and Starosta de Waldemar (2015) for China, and Lo Turco and Maggioni (2016) for Turkey.

[11]As shall be presented in the rest of the paper, we work with logistic regression models to explain product market entry decisions. Working at a finer product level would cause the dependent variable to vary very little since most of the time it would show a zero value.

[12]We dropped East Europe, Neutral Zone, Rest of America, Free Zones or Special Categories, etc. because we focus on individual exporting countries.

[13]However, we report bilateral proximity at the HS-4 level while Poncet and Starosta de Waldemar (2015) report bilateral proximity at the HS-6 level.

[14]Nomenclature of Territorial Units for Statistics.

[15]Given that: 1. firm influence on the reference set applies to less than 2% of all firms, 2. the presence of such a direct link does not have a straightforward consequence on the density variable, and 3. the way the dependent variables are defined avoids the circular link between firm export revenues in 2002 - regional comparative advantage (see Section 4); we think that endogeneity is not a concern in the analysis.

[16]This choice is driven by the empirical fact that the linear probability model, as an alternative, predicts negative probabilities for our dataset.

[17]Although in our product level estimations products are defined at the HS-4 level, here we define the initial product mix at the HS-2 level because the finer the product definition the higher the number of unique product mixes. Since α_{im} enters the estimation as a factor variable and a single observation is not sufficient for its estimation, all unique product mixes are dropped from the sample.

[18]Both value added and labor are harmonized using deflators at the third level of Nomenclature Economique de Synthèse (NES), which is the summary economic classification provided by INSEE including 114 positions.

[19]For reasons of parsimony, we do not define the dependent variable as the ratio of export revenues obtained from a new product to total export revenues from existing products. Since firm revenues in the existing market could be in a decline, stagnation, or growth period, further controls need to be added to the right hand side, when the denominator is defined using the revenues from existing products.

[20]Note that column (d) is not an exact replicate of column (b). In (b) OTH_{ik} considers both the number and the local embeddedness of other goods. In (d), OTH_{ik} is replaced by $AVG{-}OTH_{ik}$, the average local embeddedness of other continuous goods. This is because

the size of the initial product mix, which is introduced to the model to proxy for product-mix effects, contains continuous products and dropped products, and hence is highly correlated to the number of other goods, capturing one of the dimensions represented by OTH_{ik}.

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