



CSC WORKING PAPER

**THE COMPETENCES OF FIRMS
ARE THE BACKBONE OF ECONOMIC COMPLEXITY**

Tullio Bucciato

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THE COMPETENCES OF FIRMS ARE THE BACKBONE OF ECONOMIC COMPLEXITY

Tullio Buccellato

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Abstract

This article studies patterns of diversification of products and accumulation of competences both at firm and province level (NUTS 3) in Italy. The analysis starts from the perspective of firms, which implement diversification as a strategy to grow on the market through the expansion of the internal knowledge-base. Results show that growth goes hand in hand with diversification. However, diversification is difficult to be achieved and the majority of firms remain specialized in single good productions. On impact, diversification is accompanied by a loss in efficiency, especially when it comes to diversification in unrelated classes of products. Diversified firms exhibit portfolios of less ubiquitous goods, suggesting that sophistication requires enhanced levels of competences. This result holds also for provinces. The analysis continues looking at the impact of economic complexity on the prosperity of the Italian provinces and shows that more complex economic fabrics are associated with higher levels of value added per capita. Economic complexity evolves following a self-strengthening path, as proximity with original core competences is key to acquire new ones and more diversified economies are naturally more likely to catch new production opportunities. This study contributes to the analysis of heterogeneity of the performance of firms and sheds light on how path dependency in the accumulation of competences is one of the key factors at the roots of the gap in development across territories within countries.

JEL Classification: L25; O25; O11; O12

Keywords: Diversification; Economic complexity; Heterogeneity; Competences; Knowledge; Innovation.

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All the views expressed in this paper are of the author and do not necessarily reflect those of the institution where he works. The author is responsible for any mistake contained in this work.

"A less developed country that produces no cars cannot benefit from the invention and adoption of a better car-producing robot in Japan (...), nor can it benefit from the factor-price equalization effect of the accompanying Japanese investments, since it cannot shift labor force out of its (nonexistent) auto industry as the theorem's logic requires."

Baumol, 1986

Introduction

Firms display a wide heterogeneity in performance, with a restricted number of firms obtaining outstanding results, a large number of firms with average positive or negative results and a tail of very poor performers that struggle to float on the market. Disparities arise also at the aggregate level across territories. Absolute divergence across countries and regions is a prevailing and persistent phenomenon and, where convergence takes place, it is only across "clubs" of countries and regions with similar characteristics (Baumol, 1986). This paper contributes to explain heterogeneity from the perspective of firm-level disparities that translate into gaps of performance across territories. The common denominator linking the micro and macro perspective is *productive knowledge*, which accumulates in firms willing to grow and propagate into the territories where the same firms operate. This leads to a virtuous reciprocal exchange, for which firms promote the development of territories and, in turn, territories are the pool of competences to which firms can freely access.

Firms' ambition of expanding encounters its natural limits in the finiteness of the markets. To overcome this obstacle, firms are pushed either towards the penetration of new geographical markets, or to the introduction of new products, or a mix of both. This paper focuses on diversification strategies as a key determinant of the performance of firms. A sustainable path of development for firms stems from the capability of developing internal knowledge, which finds its direct expression in the process of diversification with the introduction of new products on the market. Core competences are the boundaries delimiting the perimeter in which the firm can expand by catching new productive opportunities; in turn, these last give impetus to widening knowledge and enlarge the pool of internal competences within the firm. Individual behaviours of firms add up to the overall degree of economic complexity of the territory where firms operate, determining its future patterns of economic development.

This paper analyzes economic complexity across Italian provinces starting from the perspective of individual firms expanding their activity across multiple product lines. The study builds upon and links together two streams of the economic literature – the competence-based perspective of the firms (Penrose 1959, Nelson and Winter 1982) and the theory of economic complexity (Hidalgo C. A., B. Klinger, A.-L. Barabási, R. Hausmann 2007, Hausmann and Hidalgo

2010, Hausmann and Hidalgo et al 2011). The concept of *proximity* in knowledge expressed in terms of distances projected in the *product space* is also in line with the notion of *related variety* as a key channel to let knowledge spill over and contribute to regional economic growth (Boschma 2005; Frenken, van Oort and van Verburg 2007; Boschma and Iammarino for an extensive review on the topic and an empirical analysis on Italian provinces).

The empirical analysis is based on the Istat-PRODCOM dataset, which provides information on the portfolios of products sold by more than 33,000 Italian firms and covers the period 2005-2013. We find evidence that the growth of firms goes hand in hand with the diversification of their products. After the crisis of 2008, strategies of specialization have prevailed on those of diversification, reverting the trend observed over the period 2005-2007. The relationship between diversity and ubiquity of products is found to be negative both at the firm and at the province level (NUTS3). Italian provinces with enhanced level of economic complexity exhibit higher levels of value added per capita.

The rest of the paper is structured as follows. In Section 2 we recast the theoretical background linking the micro- and macro- perspectives on diversification and economic complexity. In Section 3 we describe the data set used and provide some descriptive statistics. Section 4 presents the process of diversification and its link with dimensional growth at the firm level. Section 5 focuses on the economic complexity of Italian provinces and how this impacts their patterns of development. The final section concludes.

Literature background

The central point of this paper is productive knowledge and its patterns of accumulation through the acquisition of new competences and capabilities. Restricting the focus on productive knowledge allows to measure competences and capabilities present in a firm or a territory by the set of goods made within themselves. Initially, accumulation of productive knowledge takes place within firms, which are naturally pushed towards diversification strategies to grow beyond the finiteness of the markets where they operate, given the constraint of their initial pool of resources:

"The possibility of producing new products and acquiring new markets frees the firm from the restrictions on its expansion imposed by the demand for its existing products, although not from the restrictions imposed by its existing resources,"(Penrose 1959).

Gradually competences build up and accumulate in territories where firms operate generating a self-enforcing process, in which firms benefit of knowledge in their geographical neighborhood and new competences acquired at the firm-level bolster spill over of *common* knowledge within territories.

The importance of competences for the expansion of the firms has found wide space also in the literature on corporate management, this can for example be read in the *incipit* of Prahad and Hamel (1990):

"The most powerful way to prevail in global competition is still invisible to many companies. During the 1980s, top executives were judged on their ability to restructure, declutter and delay their corporations. In the 1990s, they'll be judged on their ability to identify, cultivate, and exploit the core competencies that make growth possible – indeed, they'll have to rethink the concept of the corporation itself."

Enhancing the diversity of the production portfolio is complex both at firm and country level. As regards firms, Ansoff 1957 identifies four possible ways for growing –market penetration, market development, product development and diversification. Diversification is the hardest to be implemented as "it calls for a simultaneous departure from the present product line and the present market structure". Diversifying therefore implies stretching firms' knowhow beyond its comfort zone to explore new production horizons, which might to different extent be related to the core competences of the firm. Hausmann and Hidalgo et al.(2011) observe that at the country level the process of accumulating capabilities can be hindered by a self strengthening "chicken and egg" problem. The acquisition of new "chunks of knowledge" is very costly where the initial product space is reduced as, on the one hand, knowledge is the essential prerequisite to develop new products, but, on the other hand, incentives to accumulate knowledge are very limited in places where there is the lack of an industrial basis that can turn newly acquired capabilities into marketable products.

If related and especially unrelated diversification are not easy to be implemented, "there is no need to deny, [...], that a variety of potential gains are provided by grouping activities irrespective of their character; risks can be spread, the general managerial capability of the firm can be kept fully employed and the allocation of finance can be planned from the centre. None of this is in contradiction with the principle that it will pay most firms for most of the time to expand into areas of activity for which their particular capabilities lend them comparative advantage" (Cit. Richardson 1972). At the aggregate level, continual diversification is the way to guarantee "a growth miracle sustained for a period of decades" for countries and nations (Lucas 1988).

The fact that a difficult strategy to undertake has undeniable benefits is at the roots of persistent heterogeneity in the patterns of economic development of firms and territories. Diversification implies an initial cost that not all firms/territories are capable to bear and not all firms are able to overcome encountering a limit in their capabilities and organizational skills at the firm level, knowledge and institutional systems, at the country level. It follows that development of both firms and countries is path dependent in relation to their initial pool of competences and the range of products that they make. Moreover, firms that achieve good levels of diversification can experience a continuous process of feedback between internal

research activities and production of goods, prompting a virtuous circle for enhancing the accumulation of capabilities. Where a firm stands will somehow affect its future patterns of development as initial capabilities tend to affect the acquisition of new ones and therefore the perspectives of expansion of the firm itself (Dosi, Grazzi and Moschella 2014). At the country level, the range of competences and the portfolio of products develop jointly for a reciprocal requirement of coexistence (Hausmann, Hidalgo et al. 2011).

Firms' strategies of diversification can be either aiming at expanding production towards businesses with a similar knowledge base leveraging on the core competences of the firm – related diversification- or in businesses that are more at odds with it –unrelated diversification. Related diversification is often realized to broaden the participation of the firm in the value chain where it operates, possibly with the intension of enhancing its share of value added. Economies of scope and scale as well as maintaining low coordination costs are effects that tend to be more pronounced for diversification in related productions (Markides 1992). Unrelated diversification may instead reflect a willingness of diversifying the product portfolio of the firm in new markets with the aim of stabilizing sales. At the aggregate level it is observable that countries tend to diversify in the proximity of their product space, expanding production requiring new capabilities in the “neighbourhood” of their knowledge (Hausmann, Hidalgo et al. 2011).

Diversification for both firms and countries is easier when it capitalise on the stock of capabilities already available. However, the product space where firms operate has a completely different structure with respect to the one that characterizes national systems. Firms are active in sectors that constitute parts of the overall product space of national systems. It follows that capabilities accumulated by firms tend to be much more focused around the competences required to operate in a specific part of the product value chain and hence much closer to the core competences that the firm already has. The pattern of diversification across different sectors can happen in cases when sectors share a common set of knowledge. The variety of firms operating across different sectors constitute the economic system with its complete set of capabilities, which is naturally richer.

Such difference becomes crucial when analysing the set of competences in a comparative perspective across firms or across countries. Across countries diversity tend to differ in a cumulative fashion, by which more complex economic systems share the set of capabilities of simpler ones and the reverse is not true. In general, for firms this might be possible only when looking at specific fragments of the overall value chain. Nonetheless, the concept of ubiquity holds for both firms and countries. Only a restricted number of firms and countries with enhanced levels of capabilities can make more complex products. It is therefore an open question whether firms, as countries, are more likely to make less ubiquitous goods

when they are able to diversify across a wider sector of products and is something that will be object of our empirical analysis.

The impact of diversification on growth is characterized by similar mechanisms at firm and country level. Both firms and countries are faced with new productive opportunities that they can to different extents be able to intercept. In principle, the wider is the set of competences owned, the more likely firms and countries can be receptive to new productive opportunities. Various studies have documented how diversification of products at the firm level matters in determining the size of the firm, with product count being an important factor affecting firms' expansion more than others such as age (among the most recent Konings et al. 2004). Such finding is in line with the evolutionary perspective of firms' growth dynamics proposed by Sutton (1998) - firms grow expanding their product portfolio. Looking at the aggregate effect of economic complexity Hausmann, Hidalgo et al. 2011 find a strong positive relationship linking levels of GDP per capita and complexity. Moreover, countries that on average are richer with respect to others with similar levels of economic complexity tend to exhibit slower paces of growth.

If firms and territories exhibit development paths largely explained by their level of diversification, it is key to understand what influences the patterns of diversification and how they evolve over time. Diversification is a function of the compatibility of the competences present at a given time in a firm or territory. New competences will be acquired more comfortably if they can be combined with the already existing ones (Hausman, Hidalgo et al. 2011). Each product is the expression of a set of capabilities and the more it is likely to be combined with the production of other goods, the larger is the set of capabilities it expresses. Firms and territories characterized by knowledge intensive productions are therefore more likely to enhance the diversification of their portfolio of products and improve their potential of growth. Parallel and very much connected to the literature on economic complexity is the one on agglomeration and related variety. This stream of literature shifts the momentum of the debate on regional specialization (Marshallian externalities) *versus* regional diversification (Jacobs's externalities) to the focus on the related variety as a key factor enhancing future patterns of growth (Boschma 2005; Frenken, van Oort and van Verburg 2007; or Boschma and Iammarino 2009). All these strands of literature converge on the idea that proximity and complementarity of competences are the two key factors prompting effective knowledge spill over and expansion.

Concluding, the literature background of the current paper suggests that heterogeneous levels of productive knowledge within firms and territories are a key factor to explain their patterns of growth and economic development. Disparities in economic prosperity stem from path dependency in the accumulation of capabilities with respect to their initial conditions. The self-strengthening process triggered by capabilities and their immediate application in

production can generate divergent patterns of growth across firms and territories. This can have pessimistic and optimistic implications. On the pessimistic side, backwardness can carry severe consequences generating poverty traps and long term divergence in economic development (Pritchett 1997). In addition to this, processes of industrialization tend to be geographically concentrated in specific locations within countries and, even when convergence is present across borders, divergence might be the persistent pattern within countries (Traù 2010, Derviş 2012). On the optimistic side, looking at goods and delocalization as channels to exchange productive knowledge, the enhanced level of internationalization of economic activities in the globalised era has enlarged the learning opportunities of less industrialized countries enhancing convergence across countries (Subramanian and Kessler 2013).

The data to measure diversification and descriptive statistics

The database used for the current study is the Italian edition of PRODCOM (from the French: *production communautaire*), which provides statistics on the production of manufactured goods. PRODCOM is a survey run by Istat - the Italian National Statistics Institute and the data have been accessed through the Adele Laboratory- an infrastructure for safely accessing micro-data, run in-house by Istat.

The database reports multiple rows for each firm with information on the repertoire of the company. Data is available starting since 1999 but the sample is unstable until 2005, due to changes in the stratification of the sample with an impact on the weight of different sectors. For this reason the analysis covers the reduced time period 2005-2013, which is nonetheless very interesting as it allows to study the effects of the crisis started in 2008.

The number of products –PRODCOM 8 digits- is used as the key measure for diversification. Such a measure is easy to interpret and already used in the literature by various authors (Konings et al. 2004; Sutton 1998). Using the structure of PRODCOM it is also possible to draw a distinction between related and unrelated diversification depending on whether it happens within or outside the same class of products (PRODCOM 4 digits, corresponding to NACE 4 digits). Although the product count is the most straightforward measurement of diversification it does not allow to take into account the degree of distribution of sales across the several business lines. For some parts of the analysis and to offset this inconvenient, it is used the share of sales of the primary business line as a measurement of specialization of the firm. Nonetheless we are still not able to capture the diversification across different varieties of the same product that might be still considered as a type of diversification (Penrose 1959) or, when it comes to firms operating across several classes of products, the degree of internal coherence, in the sense that does not capture certain technological or organizational characteristics that might be common to more classes of products (Dosi, Teece, Rumelt and Winter 1994).

Table 1 describes the composition of the sample looking at the number of products and firms considered. The sample is quite stable with a slight slowdown in the number of companies and products. The number of products passes from 3,883 in 2005 to 3,374 in 2013, and the number of firms from 39,895 to 34,478 over the same period. The reduction of the sample is quite evenly distributed across all sectors of the economy with the exception of the food and live animals and the apparel, ships and aircraft and machinery. All sectors have not reduced or just slightly increased in terms of products. The sector ships and aircraft experiences a slight increase also in the number of firms passing from 376 in 2005 to 388 in 2013.

In 2008 took place the transition from the NACE Rev.1 to NACE Rev2. To calculate the figures contained in Table 1, a mapping of the macro sectors reported has been produced. The sample and its distribution across sectors is stable. All parts of the analysis reported in the next sections of the paper are immune from any bias that such change could have induced. In particular, the analysis of relatedness of products made by firms, is always conducted looking at single years that are obviously referring to the same classification.

Table 1: number of firms and products (PRODCOM 8 digits) by sector in 2005, 2009 and 2013.

	2005		2009		2013	
	Number of products	Number of firms	Number of products	Number of firms	Number of products	Number of firms
a.Mining & quarrying	44	893	31	768	32	687
b.Food & live animals	340	3121	343	2823	346	3112
c.Beverage & tobacco	43	489	40	409	39	469
d.Textile	232	3062	210	1666	207	1547
e.Apparel	123	1855	124	1713	123	1791
f.Leaner & Footwear	55	1744	47	1065	47	1191
g.Wood, pulp and paper	209	4156	155	2153	153	2121
h.Books, CDs	62	1599	28	770	29	779
i.Chemical & health	534	1370	462	1197	472	1312
l.Rubber & plastic materials	159	1929	140	1799	131	1897
m.Construction materials	160	2778	146	1911	139	1932
n.Metal products & parts	475	6481	455	5929	439	6133
o.Electronics	109	522	184	734	176	871
p.Machinery	632	4975	739	4657	702	4804
q.Motorvehicles	75	682	75	564	67	555
r.Ships & Aircraft	58	376	66	411	60	388
s.Other	573	3863	217	4896	212	4889
Total	3883	39895	3462	33465	3374	34478

Diversification and growth of firms

The analysis starts up describing the patterns of diversification measured as the count of the products (PRODCOM disaggregated at the 8 digit level) in the portfolios of single firms. Diversification results a rare strategy with only a restricted number of firms that prove able to reach a wide range of products and that becomes even harder in periods of contraction of the economic cycle. Figure 2 shows the distribution of firms according to the number of products that they make at the beginning of the period considered before the start of the crisis – year 2005, just after the beginning of the crisis– year 2009, and at the end of the period – year 2013. The majority of firms is specialized on a single product during all the period considered, with an increase in specialization following the crisis – in 2013 the share of single product firms is of 65% of the total number of firms considered. As the number of products increases, the number of firms with a corresponding range of products in their portfolio decreases sharply, with the relation between the two variables taking the shape of a negative exponential function.

Figure 2: evolution of the degree of diversification over time

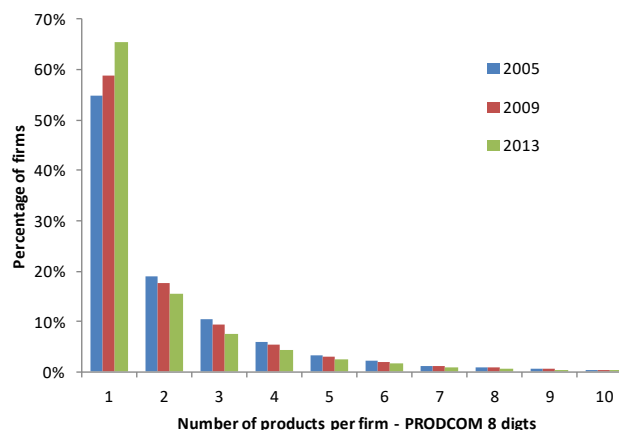
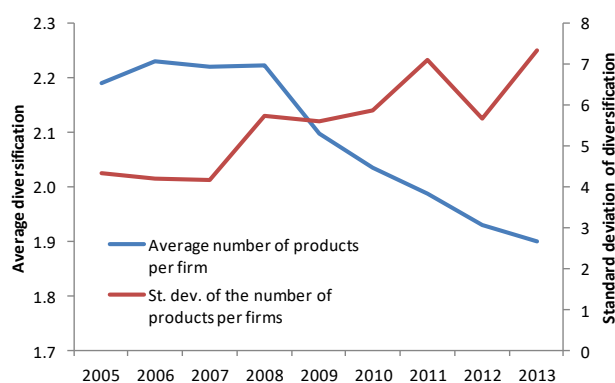


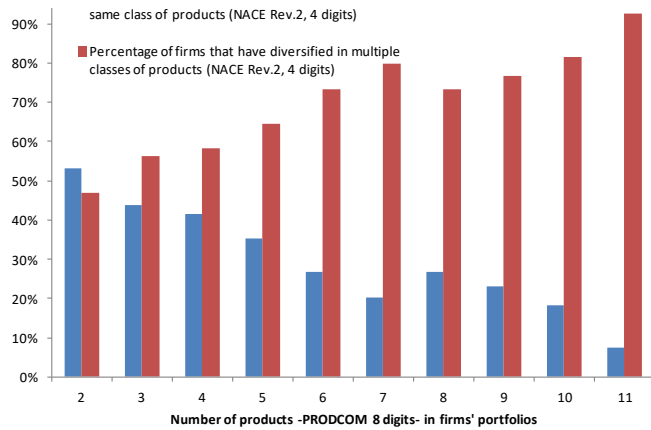
Figure 1: dynamics of diversification over time



The results are confirmed by the analysis of the dynamics of diversification over time considering the average change in the number of products made by single firms before and after the economic crisis of 2008 and the evolution of standard deviation. Over the period 2005-2007, the average diversification of firms slightly increased, whereas over the period 2008-2013 it continuously fell. Strategies of diversification have continued diverging during all the period considered as shown by the ascending slope of the standard deviation, that has experienced a 70% increase over the period considered passing from 4.3 in 2005 to 7.4 in 2013.

As firms increase the number of products in their portfolios they stretch their competences to new types of good that are increasingly more distant from their initial set of core competences. Figure 3 shows where firms diversify in relation to classes of products (NACE Rev.2, 4 digits). The higher is the degree of diversification, the greater is the probability that firms develop into

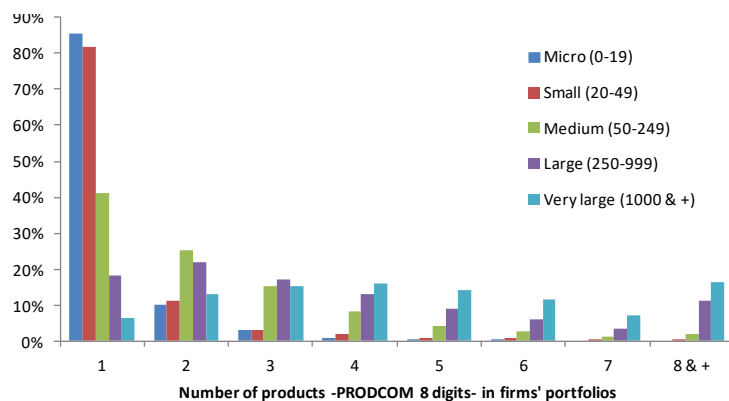
Figure 3: percentage of firms that expand in related and unrelated products and degree of diversification, 2013



The majority of firms with just two products are active in a unique class of products, already in the case of three-product portfolios the percentage of firms that have diversified across multiple classes of products slightly exceeds those in a unique one; the pattern continues till the point where 92.5% of firms with 11 products in their own portfolios are active on multiple classes of products. These descriptive statistics start to shed some light on the process of accumulation of competences and knowledge within firms. Provided that firms do what they know and that unrelated diversification is more difficult than related one, larger product portfolios correspond to superior knowledge-bases, which enhance the attitude of firms to acquire new competences in production processes further from the original core competences.

The analysis continues looking at the relation between diversification and dimensional growth of the firm. The results suggest that the size of the firms and their portfolio of products expand together and firms with wider range of products exhibit larger

Figure 4 : diversification and size of the firm

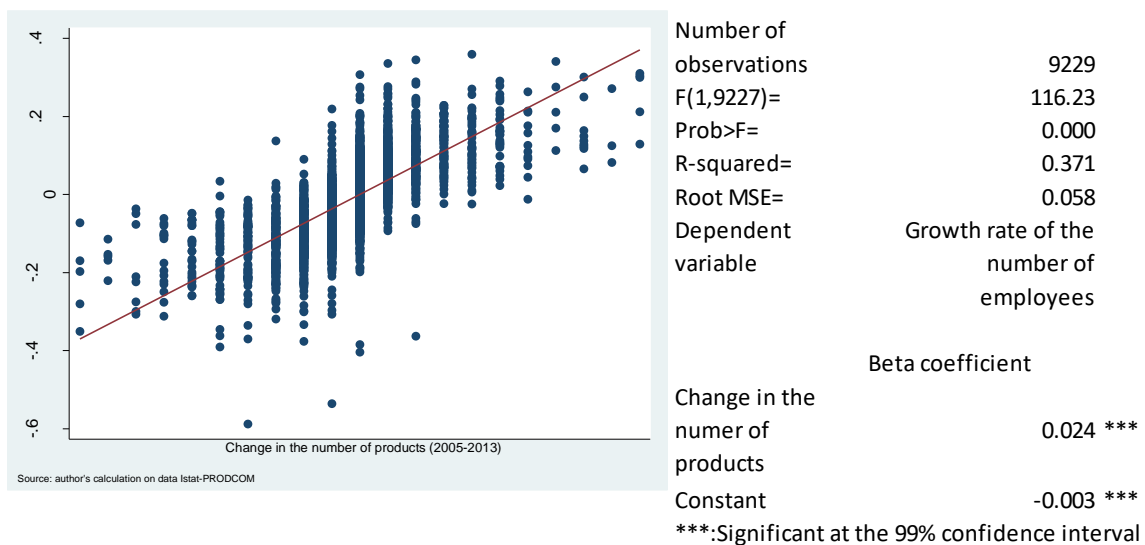


size in terms of number of employees. Figure 4 shows the distribution of firms according to size and degree of diversification. 85% of very small firms with a size below 20 employees are specialized in a single product, 10% in 2 products and the remaining 5% does not exceed four products. When it comes to very large firms with 1000 employees or more, only the share of 6% is specialized in a single product, 66% produces four products with some firms exceeding the 90

products. A strong positive association between size of the firm and the number of business lines in its product portfolio was first found by Gort (1962) on a sample of 721 firms. To explain these results, Gort advances the idea that diversification is a form of investment and as such contributes to the growth of the firms. In turn, larger firms are able to attract more capital and to realize economies of scale in their activities of research and development. In line with this hypothesis, Gort shows that multi-product firms exhibit higher technical personnel ratios, which is a good measure of research intensiveness.

This result is also confirmed looking at dynamics of growth and diversification. Figure 5 suggests that firms' growth is deeply inter-linked with diversification. The figure is based on a panel of 9,229 firms that are present in PRODCOM database over the period 2005-2013. The GLS regression of the growth rate of the number of employees as dependent variable and the change in the number of products in the portfolio of the firms as regressor shows a positive and significant relationship between the two variables with a coefficient of 0.024 and an r-squared of 0.371. Such results might be biased as the two variables might move simultaneously. The fact that firms enlarge following the expansion into new product lines is quite logic. Less straightforward but nonetheless possible is the fact that employees can bring new competences and directly contribute to the expansion of the arrays of products in firms' portfolios. This suggests that any conjecture on causality between the two variables might reveal misleading. Adopting a cautious perspective, the relation can be measured through a correlation measure without making any assumption on the direction of causality. A Bonferroni adjusted correlation of the magnitude of 0.6087 and significant at the 99% level has been estimated. Even if of lower magnitude, the relation holds also when considering dimensional growth in terms of sales.

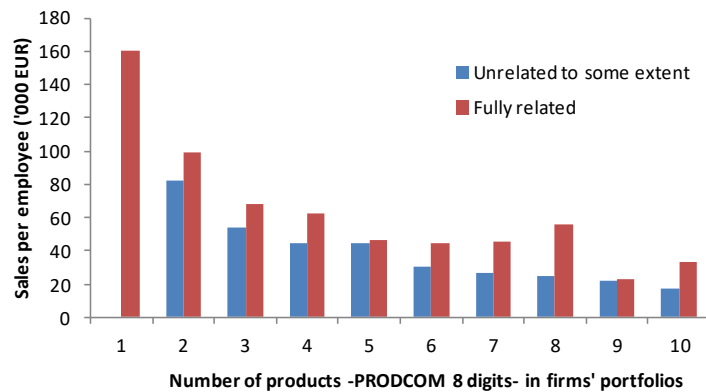
Figure 5: dimensional growth and diversification over the period 2005-2013



Expansion for firms requires a continuous acquisition and update of competences that not all firms are ready to achieve. Acquiring new “chunks” of knowledge is hard and transform them in productive knowledge even harder. The data suggest that firms undertaking diversification strategies are prone to a loss of efficiency¹, especially when diversification strategies are directed to production lines less related to core competences. The fact that integrated mode of

production tend to be more efficient than conglomerates is a simple consequence of the fact that lateral or related diversification can leverage more on existent capital technical skills of the business with respect to conglomerate where such factors are more

Figure 6: sales per employee and diversification, 2013



heterogeneous (Teece, 1980). Figure 6 shows a clear descending pattern of sales per employee as diversification increases. Completely specialized firms exhibit an average productivity that is around four times as much as the productivity of the firms active in ten product lines. For all the degree of diversification from 2 to 10 products, sales per employee are even lower when diversification is realized across different classes of products (NACE Rev.2, 4 digits). The efficiency loss associated with diversification, especially when this happens farther afield, is expected to translate into lower profitability of the firm. Such result is in line with the finding by Wernerfelt and Montgomery (1988) of a negative relationship between diversification and profitability. Such results is echoed also in Markides (1995), who found that firms that adopted strategies of refocusing in the 1980s enhanced profitability.

These results are confirmed by a pooled regression analysis conducted over the period 2005-2013 over a sample of 48,259 observations. The regression is implemented considering as dependent variable the logarithm of sales per employee, as regressor the natural logarithm of the number of products in each firm portfolio, year dummies to control for time variance and robust standard errors. The estimated relation is negative, robust (99% confidence level) and strong in magnitude (-0.87). When adding a control for the percentage of sales in the prevalent classes of product (the one with the higher percentage of sales within firm portfolio), the coefficient for

¹ With PRODCOM, sales per employee is the only proxy that can be used for measuring productivity. Such measure has been used also in Bugamelli, Schivardi and Zizza (2008), where it is argued that the evolution of sales can better capture the changes of the production chain that might follow the reorganization of activities. As diversification imply a strong reorganization, such measure can provide some useful information.

diversification remains negative and significant but slightly rescaled upward (-0.82). As expected the coefficient for the percentage of sales the prevalent class of product is positive (0.54) and significant (99% confidence level).

The results on the relation between diversification and productivity have to be interpreted with caution. First of all the Istat-PRODCOM database does not allow to calculate total factor productivity and the time span is not sufficient to draw a distinction between short and long term effects of diversification. In this sense are interesting the findings of Schoar 2002. Using TFP as a comprehensive indicator of efficiency, she shows that, on impact, firms that diversify experience a loss in productivity, mainly due to the loss of efficiency in incumbent plants, which offset the gains in productivity of newly acquired plants. This results are explained for the fact that managers shift their attention towards the new segments for a sort of “new toy” effect”. Despite the initial costs, diversified firms compared in cross section with stand-alone firms, are more productive.

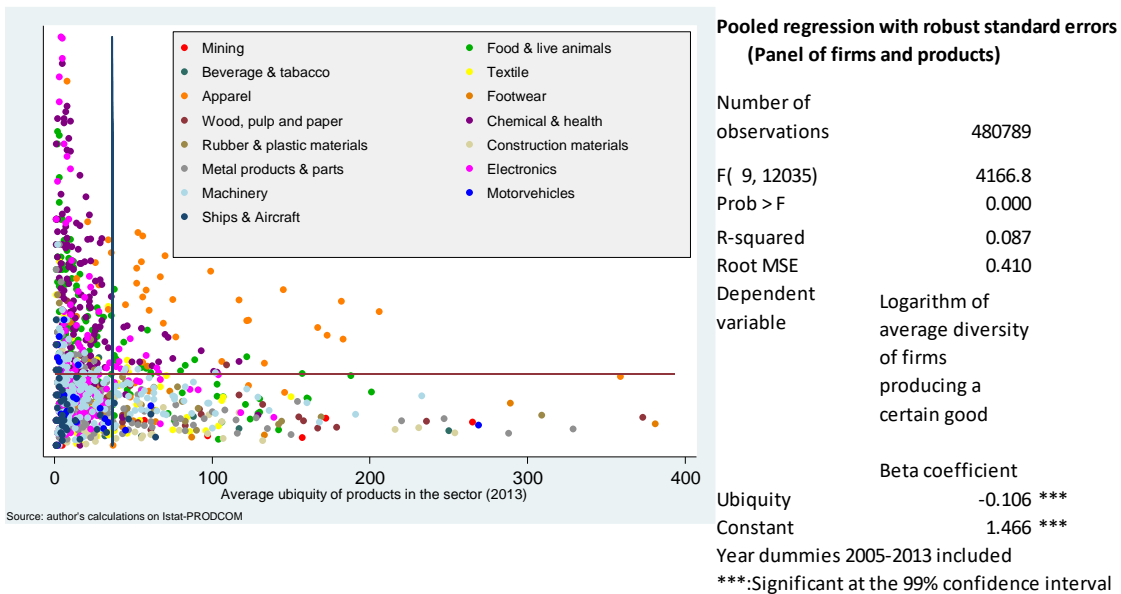
Summarizing, diversification is one of the key strategies leading firms to expansion through the enlargement of their competence base. Only a limited number of firms prove able to pursue with success strategies of diversification. The departure from core competences can weaken, at least initially, the efficiency and the organization of the firm raising complexity to a higher level that not all firms are willing or able to cope with. Nonetheless, well implemented strategies of diversification results in higher efficiency and accompany the dimensional growth of the firm.

The components of complexity build up from firms and characterize territories

In the framework proposed by Hausman and Hidalgo 2009, diversity of the products exported is just one the two pillars of economic complexity. The other building block of complexity is the ubiquity of products simply measured as the number of countries that export a given product. *Ceteris paribus*, as ubiquity increases, economic complexity decreases. One of the key results presented by Hausmann and Hidalgo 2009 is that countries that have improved levels of diversification exhibit lower average levels of ubiquity. We extend their framework to the case of firms and find confirmed also at the firm level that more diversified portfolio of goods exhibit also lower average ubiquity of their basket of goods. This implies that firms with a wide set of capabilities can produce goods for which only few firms will have all the necessary capabilities to operate at that level of complexity. Therefore, also at the micro-level the variety of products made by firms and their degree of ubiquity are important to qualify the overall complexity of capabilities expressed by firms.

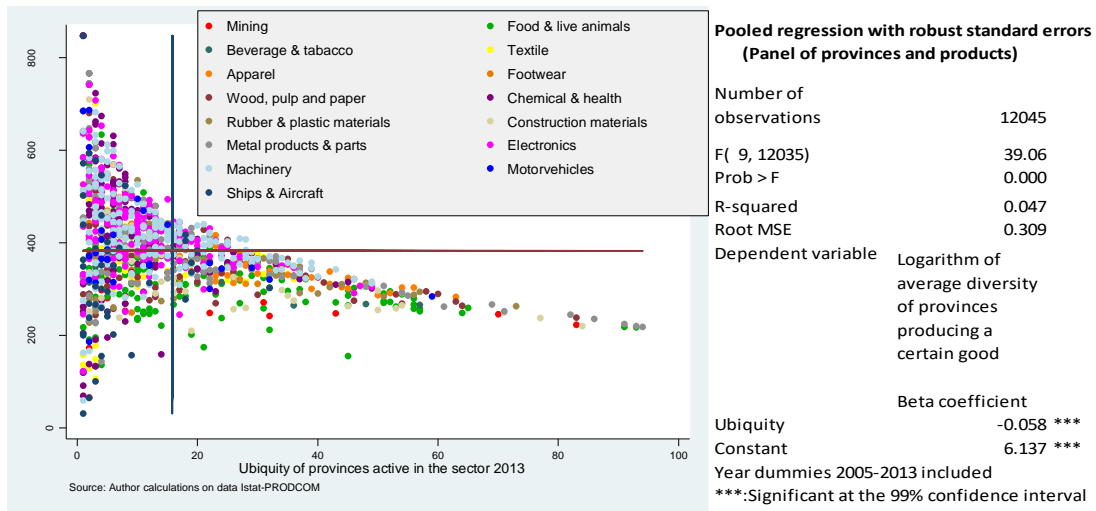
Figure 7 shows the average ubiquity and diversification of firms operating in aggregated macro-sectors. Sectors such as electronics and chemical and health are among the sectors with firms characterized by both high levels of diversification and ubiquity of their portfolio of products. Other sectors such as apparel and food and live animals are characterized by greater differentiation in the level of complexity within them. Drawing a differentiation of sectors in terms of their degree of complexity on the basis of firm-level data might be nonetheless misleading for the already mentioned reason that firms, as opposed to countries and territories are active only on selected parts of the value chain and do not increase knowledge sequentially and with a cumulative pattern. At this stage of the analysis it is nonetheless important to stress that the firms tend to exhibit a negative relationship between the average ubiquity and average diversification of their product portfolio. These results are confirmed also through regression analysis. The log-form regression of the average diversity of firms producing certain products and the average ubiquity of those products provides clear and robust evidence of the two. The estimated coefficient with robust standard errors and controlling for the time variant factor over the period 2005-2013 is -0.058 with a 99% confidence interval.

Figure 7: average diversity and ubiquity of firms in macro-sectors, 2013



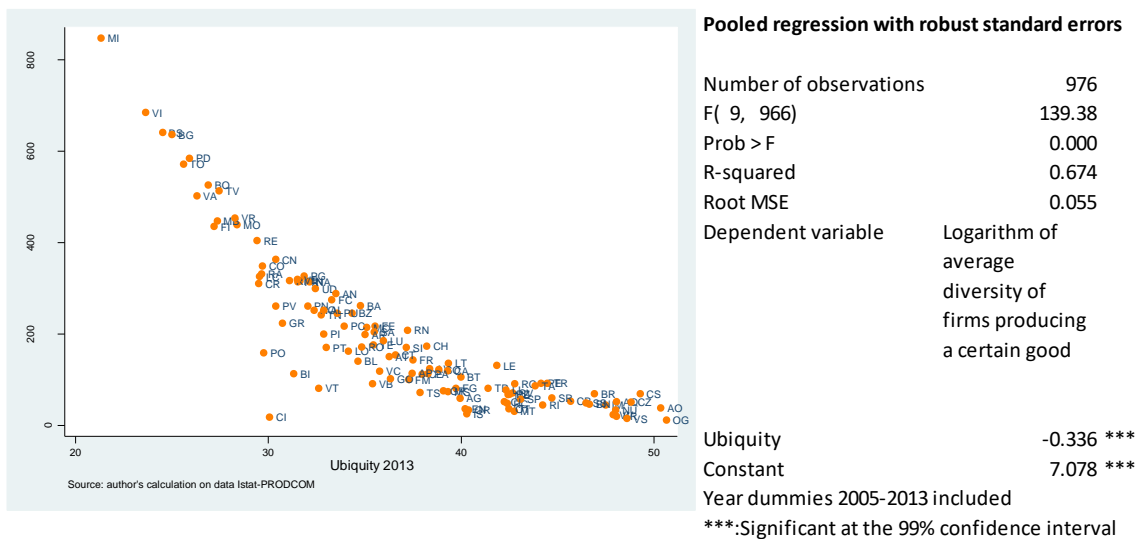
The next step is to categorize the product space of Italian manufacturing firms according to their diversity and ubiquity at the province level. We aggregate data at the level of Italian provinces – NUTS3, and the products at the PRODCOM 6 digits level. Figure 8 shows that products in the machinery and transport sector, chemical products tend to be highly complex in terms of ubiquity and average diversity of the provinces working on them. Among the least complex products there are mining products, food beverages and tobacco. The results are in line with those obtained at the country level by Hausman and Hidalgo 2009.

Figure 8: average ubiquity and diversity of provinces in sectors, 2013



The relation between diversity and ubiquity holds also when looking at Italian provinces (Figure 9). The graph shows clearly the North-South divide of Italian provinces. Milan exhibits the greater level of diversity and ubiquity followed by other provinces concentrated in the North West. At the bottom one can find Ogliastra, a province in Sardinia, and other provinces located in the Southern part of the country (exception made for Aosta, in the Northern part of the country but with a territory constituted mainly by mountains). Regression results obtained on a panel of 108 provinces over the period 2005-2013 are stronger with respect to the case of sectors, with an estimated coefficient of -0.34 significant at the 99% confidence level and r-squared of 0.67.

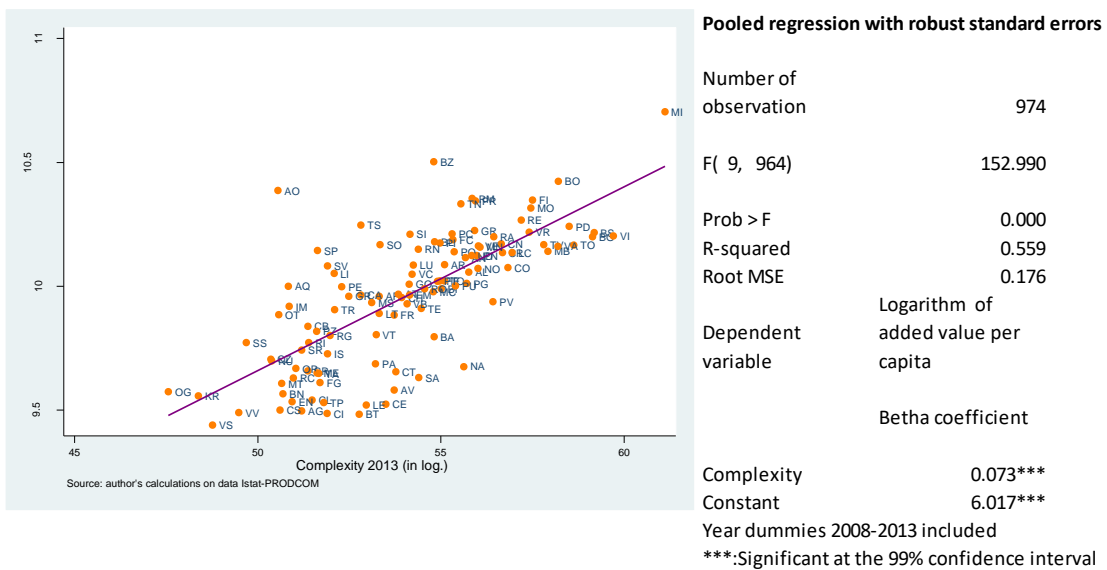
Figure 9: diversity and average ubiquity of Italian provinces, 2013



Complexity, its impact on prosperity and factors affecting its evolution over time

The analysis continues synthesizing ubiquity and complexity according to the method of reflections (Hausman, Hidalgo et al. 2011) into the index of economic complexity for Italian provinces. We apply the method of reflections until the 6th iteration.² At the aggregate level, economic complexity results to have a positive and significant impact on the level of prosperity of Italian provinces. Figure 10 reports the relationship between the level of value added per-capita of Italian provinces and their level of Economic Complexity. It is first of all interesting to notice that within a single country –Italy- there is a very strong heterogeneity in the level of complexity across the territories. Consistently with expectations, Northern provinces exhibit enhanced level of economic complexity and higher levels of value added per capita. This results are in line and help explaining the great divide of productivity across Italian zones, with firms operating in North West areas exhibiting productivities exceeding by more 7% those in the Southern areas (Buccellato and Santoni, 2011). Provinces positioned below the fitted lines are those with improved perspectives of growth as opposed to those above the line, which exhibit levels of prosperity beyond their level of growth.

Figure 10: Complexity and value added per capita across Italian provinces, 2013

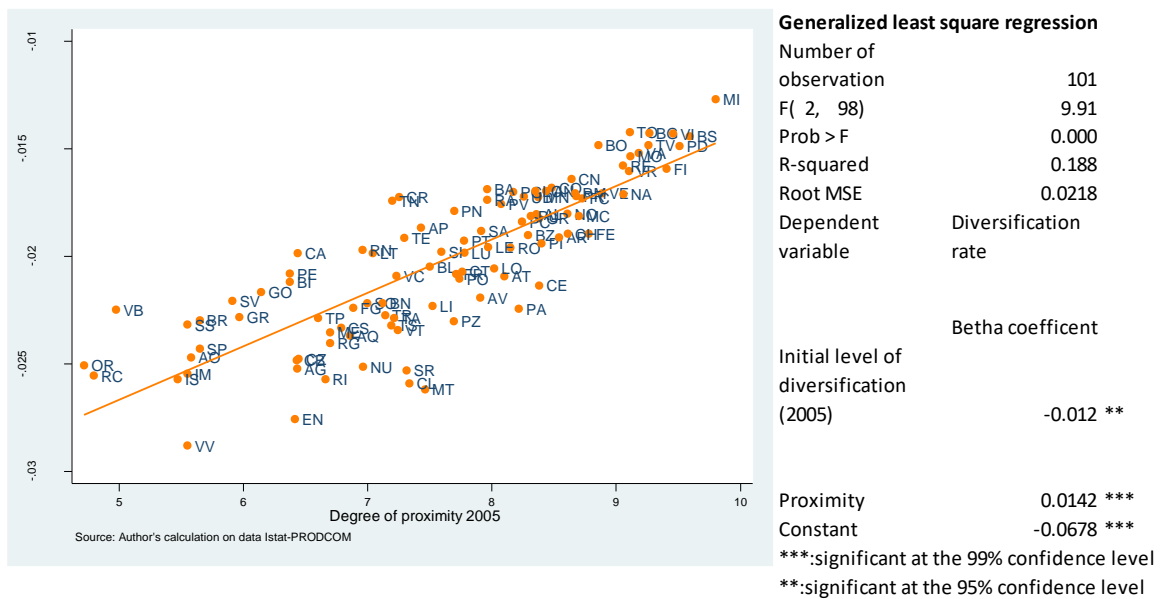


Finally we study how complexity evolves. More in particular we show how the set of initial capabilities affects the patterns of growth of the product space. To this purpose, we

² The method of reflections consists in iterating weighted averages of diversity and ubiquity alternatively using as weight the last updated iteration of one element by the other. The first elementary components are diversity and ubiquity; the results of the first iteration provides the average ubiquity of products made in one province a and the average diversity of provinces making a certain product; the third round of iteration provides the average diversification of provinces with a similar portfolio of products and average ubiquity of the products made in a province that produces a certain product. It is increasingly difficult to interpret higher iterations, which are linear combinations of the initial values of diversification and ubiquity. For a formalized explanation of the method of reflections the reader can refer to the supplementary material to the paper “The building blocks of economic complexity,” by Cesar Hidalgo and Ricardo Hausman (2009).

compute an index synthesizing the degree of compatibility of the initial knowledge base. Such index is constructed simply by counting the number of times that a certain product is made in conjunction with another one across Italian provinces. A squared matrix is constructed with the number of rows and columns equal to the number of products and each cell containing the number of times that two products are produced jointly in the same province. The logarithm of the sum of all products by province provides the indicator of proximity. Figure 11 shows the evolution of the product space over the period 2005-2013 in relation to the degree of proximity of the product space in 2005 while controlling for the initial level of diversification across provinces. Initial knowledge base appear to have a strong impact on evolution of diversity. This is confirmed also by GLS regression of the variables considered. The coefficient of proximity is positive and significant whereas the one of the initial conditions of diversity is negative and significant. This indicates that it is not just the number of products made in a province that affects its future patterns of expansion, but rather the degree of proximity to other branches of the product space.

Figure 11: patterns of diversification with respect to the degree of proximity of the knowledge base, 2013 (controlling for initial level of diversity)



Summary conclusions and policy implications

This paper contributes to the theory of complexity in a twofold way. First it shows how complexity is prompted from micro-behaviors of firms that naturally enhance their knowledge-base and portfolio of products while growing on the market. Second it shows that within countries there might be marked disparities in the degree of complexity across the territories within them. The analysis brings together the micro-economic perspective of firms considered as pool of competences that express their knowledge directly with what they make, with the theory of complexity, for which the degree of development of countries strongly depends on the degree of diversity of the economy and ubiquity of the products that they make.

Studying the distribution of firms according to their degree of diversification provides interesting insight to explain the high heterogeneity of their performance and the barriers encountered in the attempt of increasing their size. Only a reduced number of firms is able to operate on multiple product lines. Diversification is rendered difficult as often it is associated with a loss in efficiency. However, firms that are able to successfully implement strategies of diversification are strongly associated with dimensional growth and exhibit a more sophisticated (or less ubiquitous) mix of products.

The results obtained question the idea of firms oriented only towards the maximization of profits through the realization of efficiencies. Growing on the market through diversification is costly and the successful implementation of strategies of diversification has the main effect of consolidating and stabilizing the presence on the market of firms ensuring sustainable revenues on the market. Enlarging the knowledge base of the firm is key to its future acquisition of additional competences necessary for the continues development of new products and the upgrade of the ones in firms portfolio.

Strategies of diversification of individual firms sum up to constitute the complexity of territories where they operate maintaining the same property of greater diversity associated with enhanced sophistication. Territories with more complex productive fabrics are characterized by greater prosperity and are more likely to expand their knowledge basis even further. This is at the roots of a growing divide between more complex economic systems and simpler ones, that might take place between countries as in provinces within countries.

The results obtained have direct implications for economic development and industrial policy. It emerges clear that continuous growth and sustainable development for firms and the territories can be achieved only through well articulated production systems of sophisticated goods. From the industrial perspective, acquisition of new competences based on the productive experience accumulated over time is key for innovating and successfully expand production to new varieties of goods and business lines.

Industrial policy should aim at a continuous expansion of the productive knowledge base, leveraging as much as possible on the internal competences of firms and strengthening it through deep interaction with the scientific community. Policy should respond to bespoke initial conditions of firms and territories after having assessed proximity with productions towards which the firm can expand given its initial set of core competences and interpreting results looking also at the trends in demands of domestic and foreign markets. This should be done in close cooperation with policies implemented at national level, that could conduct pre-screening activities to coordinate territorial development by exploiting complementarities of multiple sets of knowledge also in different locations.

Promoting cooperation across firms can be key to ease acquisition of new knowledge. Synergies and joint competences can open access to innovation that would be otherwise not achievable stretching further the perimeter of opportunities for diversification. This can be promoted through a detailed geographical and sector mapping of opportunities that arise given the set of competences already available to guide firms in the identification of strong partners. The analysis presented in this paper provides a framework to make such assessment consistently across different dimensions – firms, territories and countries. This should maximize positive spillovers for the growth of firms and the enrichment of the product space for sustainable development of territories and countries.

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