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TECHNOLOGY AND DEMAND MECHANISM IN FIRM DIVERSIFICATION STRATEGIES. AN EXPERIMENTAL METHOD TO DISCRIMINATE THE FUNDAMENTAL DRIVERS

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Technology and demand mechanism in firm diversification strategies. An experimental method to discriminate the fundamental drivers[1]

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ABSTRACT: An essential part of any firm's corporate strategy is the choice of the business portfolio through which to compete. When the portfolio's decision involves more than one business, firms are said to implement a diversification strategy, which is put into action through the firms concomitant entry in different market segments. It implies that the nature of the market segmentation affects the firms' differentiation degree. The aim of this paper consists in exploring a method for determining the market segmentation that is *most informative* to understand firms' diversification strategies, or in other words the market segmentation that most clearly reveals about firms' main diversification drivers. Given that each business can be described according to a set of business characteristics and by using different levels of detail, in the perspective of understanding firm diversification strategies, it is fundamental to determine the directions in the space of business characteristics along which it is "mostly convenient" to claim the business diversity and which is the "best" level of aggregation at which assess the businesses boundaries. This paper proposes an experimental method to do it. In particular, it empirically discerns which of two particular criteria – functional versus technological – mostly enrich our understanding of the diversification strategies adopted by Italian plastic processing machinery suppliers, finding out the most instructive level of aggregation of the market segmentation – namely the best segment dimension – to investigate the firms diversification strategies.

KEYWORDS: firm diversification, technology, market segmentation, simulation process.

JEL CODES: L1, L6

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[1]Paper accepted and presented at the International J.A. Schumpeter Society 11th ISS Conference, Nice-Sophia Antipolis 21-24 June 2006.

SUMMARY

1. INTRODUCTION

Any firm's portfolio decision that involves a diversification strategy implies that firms enter in different product market segments[2]. As a result one of the most discerning measure of firms' degree of diversification is the number of different market segments simultaneously "occupied" by the firms. It implies that the nature of the market segmentation affects the firms' differentiation degree. In fact, as the dimension of segments grows, the firms' degree of diversification decreases; whereas the broader the overlap between the set of characteristics driving the market segmentation and the set of factors driving the firms' differentiation strategies, the higher the firms' degree of differentiation.

This paper aims at exploring a method for determining the market segmentation that is *most revealing* about firms' diversification strategies, which correspond to the market segmentation that is most instructive about firms' main diversification criteria.

The nature of the method is comparative, in particular it compares various market segmentations - which differ in terms of segmentation's criteria and levels of aggregation - with the purpose of determining the most convenient for exploring firms' diversification strategies. To give an example of possible applications, consider the case of two "products" that are devoted to the same use and that embed *different* technologies; and that, because of these attributes, are doubted to correspond to either one or *different* items in a business portfolio. A firm that offers two "products" which are devoted to the same use and which embed *different* technologies would occupy one market segment according to a "functional market segmentation" and *different* market segments according to a "technological market segmentation". Therefore, according to a "functional criterion" the firm appears not diversified, while it appears diversified according to a "technological criterion". In this case I aim at discerning which of the two criteria – functional versus technological - is more reliable to study firms' diversification strategies; or in other words, which of the two criteria do incorporate more clearly the strategic considerations underlying the diversification process. In addition, we aim at find out the most instructive level of aggregation of the market segmentation – namely the best segment dimension – to investigate the firms diversification strategies; to do this, I necessarily need to consider hierarchical market segmentations.

This comparative methodology will be empirically applied to the case of the Italian plastic processing machinery industry, whose firms' products portfolios are known at an extremely disaggregate level of detail and grouped according to different hierarchical classifications [data source: ASSOCOMAPLAST] (see section 2).

The reminder of the paper is organised into 3 sections. Section 1 focuses on theoretical background. Section 2 describes the method and the data used in the analysis.

[2] In this stage of the paper, the notion of market segment is left voluntarily vague, without any distinction between the more precise concepts of product market segment or geographic market segment - pertaining to the industrial organization literature - or the generic concept of market segment - pertaining the marketing area. Later, in the paper, this notions will be further specified.

Section 3 focuses on the empirical application of the method and on the explanation of the results.

2. THEORETICAL BACKGROUND

The concept of diversification does not lend itself to an easy conceptualisation; in fact there is still a lack of consensus as to its precise meaning. Early contributions defined “diversification” in terms of “heterogeneity of output” (Gort, 1962), where two outputs were considered to be different if they were serving separated markets, that was to say if their cross-elasticities of demand were low. Or, again, diversification was described as “an increase in the number of industries in which the firms compete” (Berry ,1975), where industry boundaries were assumed to be given. Later on (Pitts and Hopkins (1982), and Teece (1982)) the concept of “industry” was substituted with the concept of “business”, thus introducing a greater subjectivity in the definition of the diversification strategies. Along time, numerous authors have been questioned themselves on the subject of the assessment of the business boundaries and business diversity, and on the more complex issue of the extent to which this business diversity should lead to the definition of different businesses in terms of diversification strategy (for a review see Ramadujam V. and Varadarajan P. (1989)).

Theoretical and empirical solutions to identify diversification processes are often irreconcilable, given that theoretically lucid solutions are often hardly employable from an empirical point of view. Consider, for instance, Gort (1962) statement about two products being serving separated markets, conditioned to their cross-elasticities of demand being low. Consider, furthermore, that others authors add to the previous statement that two products serve separated markets if, in the short run, the necessary resources employed in the production and distribution of one cannot be shifted to the other. Evidently, such criteria hide lots of operational difficulties in their empirical application; therefore, along time, many academics have considered several, variously objective and accurate, proxies of the theoretical definitions of “separated markets”. They are essentially classifiable in two main classes of proxies: one based on “exogenous” market classifications (as the SIC hierarchical classification); the other based on “ad hoc” classifications, built up by interviewing managers and by analysing firms specific data.

The first class of proxies pertains to the traditional Industrial Organization approach. In spite of their reliability and objectivity, these proxies hide a category of potential limitations which essentially ground their roots in the way these classifications are built. According to “Machinery and Allied Products Institute” (1974), the Standard Industry Classification (SIC) system was developed by the federal government as a way of classifying all types of business activity in the economy. To do this it employs a set of reporting standards that have evolved over time based on a variety of considerations ranging from similarities in materials to product-market linkages; consequently the SIC predetermined product markets segmentations appear to be mainly based on the sharing of resources in production and raw material rather than, for instance, in marketing or R&D. For this reason, several studious have critiqued the use of SIC codes in assessing the diversity of businesses, because SIC codes inevitably – because of the way it is constructed - overlook some (potentially fundamental) strategic dimensions.

The second class of proxies was originally introduced by Wrigley (1970) and subsequently refined by Rumelt (1974). Rumelt (1974) proposed a method to discern between different (and separated) markets on the bases of their strategic independence, where two market were considered strategically independent if we could implement change on one of them without influencing the other. Instead of a single index of diversity, Rumelt (1974, 1982) employed a combination of objective and subjective criteria to classify relatedness, even based on questions directed to managers of firms, about the perceived diversity among products belonging to their firms merchandise portfolios. Even if this measurement method is not easily replicable and cumulative, the Wrigley and Rumelt studies are viewed, in Strategic Management literature, as an important conceptual advance over the exploitation of rigorous and a priori segmentations of the market, because of its capacity to flexibly capture strategic interdependences between markets.

Firms' diversification determinants

A review of the economic literature on the topic of firm diversification strategies (e.g. Penrose (1959), Panzar and Willig (1975), Teece (1982), Markides C. and Williamson P.J. (1996), Bottazzi G. and Secchi A. (2005)) reveals that traditionally researchers tended to justify the existence of multi-product firms by reasons of risk diversification and exploitation of static or dynamic economies of scope and scale (diversification determinants). In exploring such economic literature it is advantageous to make a preliminary discrimination between two major types of diversification strategies: related diversification versus unrelated diversification. According to Casson (2000), Penrose (1959/1995) and Wernerfelt (1984), all the viable diversification strategies involving physical linkages (in terms of products and geographical market) and knowledge linkages between businesses are classifiable as "*related diversifications*". On the other hand, firms are considered to be involved in "*un-related diversifications*" when they are diversified in areas where no physical or knowledge resources are shared other than financial. The same discrimination has been explained by Dundas and Richardson (1980) by means of the specific types of market failures that give rise to specific classes of diversified firms: imperfections in the product and technological markets lead to related-diversified firms, while capital market failure give rise to unrelated-diversified firms.

In spite of the abundance of economic literature on the topic of the diversification determinants, I report the contribution that Bailey and Friedlander (1982) gave to this subject by explaining, in a quite detailed way, several reasons that base the reduction in costs due to joint production of related output. They contemplate the following several cases: "separate products that naturally arise from a shared input, the presence of a fixed factor of production that is not fully utilised in production of a single product, economies of networking from joint production of networked products (e.g airlines), reuse of an input in more than one product (e.g. journal article abstracts reused in multiple indexes of articles), sharing of intangible assets between products (e.g., R&D that supports multiple products)". Each one of these points corresponds to a particular case of synergy exploitation from the "supply" point of view. Other authors studied synergies exploitations from both the demand and supply perspectives. For example, Abell (1980) – defining a business in terms of the following three elements: the customer function it seeks to satisfy, the customer groups it targets, and the technologies it uses in satisfying the customer functions sought by the targeted customer groups – highlights two kinds of synergies exploitations (on the demand side, in the first two cases; on the supply side in the third one). Again, supply and demand perspectives converge in Sutton's theory about diversification, in fact - according to the author (Sutton, 1998) - technological features, pertaining to the supply side, and consumers' preference distribution, pertaining to demand side, converge to constitute what Sutton calls the 'relevant industry pattern of technology and taste'. This pattern relates to the extend to which a firm that spends heavily in carrying out R&D on one submarket will be able to capture sales at the expense of low-spending rivals operating along other submarkets. This in turn will depend on the strength of the linkage between different submarkets, both on the demand side (and so in terms of substitution) and on the supply side (and so in terms of scope economies in R&D, or spillovers).

Each business can be described according to a set of business characteristics, and by using different levels of detail. This paper aims at determining the directions in the space of business characteristics along which it is "mostly convenient" to claim the business diversity and, and which is the "best" level of aggregation at which assess the businesses boundaries. As you have seen, different authors have answer to these questions by reminding conceptual theories about diversification. In this paper I propose a method to solve these questions from an empirical point of view.

3. METHODOLOGY

I intend to recognize the specific rationale that drives firm diversification strategies by exploiting the relationship between market segmentation and firms diversification. This is done by evaluating how the firms' "positioning" among market segments changes together with different product market segmentations, in relation to the latter's levels or criteria of aggregation.

A firm, characterised by a fixed merchandise portfolio, will exhibit different degrees of diversification in correspondence of different segmentations of the same product market. In particular the degree of diversification will be higher where both 1) the market segmentations will exhibit lower level of aggregations and 2) the overlap between the set of characteristics driving the segmentation and the set of factors driving the firm diversification strategy will be broader.

I assume that diversification strategies are mainly driven by the general, common, strategic rational of exploiting interrelations between products, either from the demand or the supply point of view, in order to achieve some cost and/or competitive advantages over rivals. This would imply that two "interrelated" market segments will exhibit a higher probability to be simultaneously captured by a firm than two "untied" ones. These interrelations cannot be defined but with reference to the direction in the product space along which such link is measured: e.g. two products can exhibit a strong link on the bases of their functionality and a weak link on the bases of their design attributes. In this case, in correspondence to product market segmentations based on functional attributes, the two products will belong to strongly interrelated market segments; while in correspondence to product market segmentations based on design attributes, the two products will belong to weakly interrelated market segments. Given that there exist as much potential links between segments as the number of different directions in the space of product market characteristics, I empirically compare different product market attributes, at different levels of aggregation, in order to estimate which one enables firms to realize the maximum value of synergy exploitation.

By varying - in terms of level and criteria of aggregation - the market segmentation, the firms positioning among the segments will vary. Consider, for example, a hierarchical product market segmentation composed by three levels of aggregations: k-1, k, k+1. Suppose that, at the $(k-1)^{th}$ aggregation level, all the segments are completely unrelated, with any opportunity of synergy exploitation, neither from the demand nor from the supply point of view: they are, in other words, "independent". Suppose that, in contrast, at the $(k)^{th}$ level of aggregation some segments are interrelated, so that a firm that occupies simultaneously these segments can exploit some sort of synergies, so achieving a certain economic advantage. This would implies that, at the k^{th} aggregation level, the probability that a firm simultaneously occupies (a certain number of) interrelated segments is higher than the probability that it simultaneously occupies (the same number) of random segments. From a probabilistic point of view this means that the interrelated segments are not independent, and hence the probability that they are simultaneously occupied by a firm would not be given by the simple product of the probability associated to the occupation of each single segment, but it would be higher. At last, suppose that, at the $(k+1)^{th}$ level, the highest probabilities of simultaneous segments "occupation" lie in correspondence of the aggregation of those segments that have exhibited synergies at the k^{th} level of aggregation.

Different linkages between segments induce different firms "positioning" among segments; in particular, the stronger the linkages between segments, the higher the probability that those segments are simultaneously occupied by the firms. Assuming that, at the lowest level of aggregation, k-1, the market is segmented in N_{k-1} segments, it follows that each firm can simultaneously capture a number of segments (n_{k-1}) which is comprised between 0 and N_{k-1}. In that case I would say that each firm can "play a number of roles (n_{k-1}) comprised between 0 and N_{k-1}".

Given that by varying the level of aggregation, it varies the number of segments in which the market is split up, hence presumably N_{k-1} differs from N_k and from N_{k+1}. The function that associates to each n_{k-1} the number of firms that simultaneously occupy that number (n_{k-1})of segments is $f(n_{k-1})$, which represents the distribution of the number of roles played by the firms in correspondence of the $(k-1)^{th}$ aggregation level of the hierarchical market segmentation. Similarly, in correspondence of the k^{th} and $(k+1)^{th}$ level of aggregation, we can empirically observe the $f(n_k)$ and $f(n_{k+1})$ distribution of the number of firm roles.

Hence, summing up, the nature of the segments linkages in correspondence of different levels of aggregation [k-1, k and k+1] forebodes different firms role distributions [$f(n_{k-1})$, $f(n_k)$, $f(n_{k+1})$] in correspondence of the different levels of aggregation. By examining how the firm positioning among segments changes together with the market segmentations, we can empirically identify the market segmentation that exhibits the maximum evidence of firms synergy exploitation. This is done by comparing the empirical distributions of the roles that the firms play in correspondence of different market segmentations, with their theoretical counterparts. The firm roles theoretical distribution is the distribution that would emerge if there were no interdependence between segments, thus if the simultaneous capture of segments were governed by a wholly random mechanism. In details, it is operationally built by replicating – in correspondence of the lowest level of aggregation - the empirical distribution of the roles played by the firms (in order to guarantee the correspondence between the empirical and the theoretical distributions), and by randomly allocating the identity of the segments simultaneously captured by the firms. Therefore, in correspondence of the lowest aggregation level ofthe theoretical firms roles distribution, I exclusively reproduce the empirically observed number of segments simultaneously occupied by each firm, but not the identity of the segments simultaneously captured, which is instead randomly allocated. At higher aggregation levels [in our example, k and k+1] the theoretical firms role distributions are obtained by grouping backward, according to the hierarchical branching paths, the segments simultaneously captured at the right lower levels of aggregation. It is presumable that the, so built, theoretical distributions of the number of firms roles will be dissimilar (in particular less concentrated) from their empirical counterparts, in correspondence of levels of aggregation higher than the lowest[3]. In fact, the closer the drivers of the market segmentation to the factors enabling the synergies exploitation [proper of the empirical case and not of the theoretical one], the higher the probability that firms role distributions will be concentrated. Hence, the occurrence of an empirical firms role distribution significantly more concentrated than its theoretical counterpart would testify the evidence of some sort of firms synergies exploitations. In that case, the probability that a cluster of segments are simultaneously "occupied" by a firm would not be randomly and homogeneously spread across segments, but would be instead concentrated on those segments that are "tied" on the basis of a specific criterion and that, therefore, if simultaneously captured, would consent the exploitation of some sort of synergies. That is why the market segmentation most revealing about firms' diversification strategies is the one that gives rise to the most concentrated firms role distribution, conditionally it is significantly different from its theoretical counterpart.

[3] Because of the building structure of this methodology, I exclude any difference between the empirical and the theoretical firms roles distributions at the lowest level of aggregation; hence I assume, in some way, the lowest level of aggregation being redundant.

4. EMPIRICAL APPLICATION

An empirical application of this methodology has been carried out on the Italian plastic processing machinery industry, whose firms' product portfolios are known at a deep level of detail, thanks to the exploitation of the ASSOCOMAPLAST database. ASSOCOMAPLAST is the Italian Plastic and Rubber Processing Machinery and Moulds Manufacturers' Association, which includes 169 firms, that account for about 60% of the total asset (sales) of the Italian industry, and that are depicted through their distinct merchandise portfolios.

The merge of all the 169 firms merchandise portfolios constitutes the whole ASSOCOMAPLAST products list, which is composed by 363 different products. They consist of different types of machines to process plastic and rubber, e.g. granulators, presses, extruders, welders, cutting and splitting machines, handling technologies, robotics, control and automatic control technology, etc..

The aim of this empirical investigation consists in finding out the segmentation of the plastic processing machinery market that most clearly reveals about the firms' main drivers of diversification (e.g. main sources of synergy exploitation from the supply and demand point of view). Because of the instrumental nature and technical features of the plastic processing machinery, plausible diversification "drivers" from the demand and supply point of view could be, respectively, the "functional driver" and the "technological driver".

In fact, the functional criterion is presumed to be one of the main purchasing rationale adopted by plastic and rubber processing machinery users; while the common technological know-how is supposed to be one of the strongest linkage between products from the supply point of view. Thus, as a starting point of the empirical analysis, I consider two different segmentations of the market of plastic and rubber processing machinery: one based on the products functionality, and one on the product technology. Subsequently, I analyse how firms position themselves among these two segmentations and how their diversification degrees vary in correspondence of the two different segmentations of the market.

The first segmentation splits up the product market in "functional segments", defined as clusters of products devoted to a similar use; the second splits it up in "technological segments", defined as clusters of products which exhibit similar technological characteristics.

Table 1. Functional segmentation [number of functional segments that compose the product market, at every level of aggregation].

Level i	*Nfi*
1	2
2	10
3	13
4	27
5	34

Table 2. Technological segmentation [number of technological segments that compose the product market, at every level of aggregation].

Level i	Nt_i
1	5
2	25
3	96
4	183
5	274
6	302
7	336
8	348

The functional classification, realised by tacking advantage of a technician consultancy, gives rise to a five-levels hierarchical segmentation[4].

[4] The five levels of the functional classification remind the different stages of the consumer purchasing choice: from the preliminary, more macroscopic phases to the more detailed and microscopic ones. The first phase is relate to the choice of the material processable by the machinery, hence the first functional criterion permits to distinguish between plastic processing machineries and rubber processing machineries[4].
The second functional criterion reflects the role played by the machinery throughout the whole plastic or rubber product manufacturing process. Therefore plastic processing machineries will be distinguished from plastic post-processing machinery, from laboratory machineries, etc..
The third functional criterion reveals the mechanical task each component is devoted to. It does not relate to the product processing cycle, but instead to the mechanical task each single component is, commonly, devoted to (e.g. tool, or equipment, or core machinery..). Finally, within each phase of the plastic or rubber production process, each mechanical instrument (tool or equipment or..) can be classified on the bases of the specific production variant it performs: this represents the forth criterion. The fifth criterion is simply a further specification of the forth.

Whereas the technological classification, realised by separating the eight-digit ASSOCOMAPLAST code associated to each product, gives rise to an eight-levels hierarchical segmentation[5]. Both the segmentations are hierarchical and nested, and exhibit different levels of products aggregation in segments, and different structures of segments in correspondence of each level of aggregation, as we you can see in the Table 1 and Table2.

[5] ASSOCOMAPLAST'S web-site exhibits a product list, consisting in 363 items, which gathers all the ASSOCOMAPLAST members merchandise portfolios. Each item, in this list, is identified by a one to eight-digit code. Higher the number of digits, deeper the level of detail used in the description of the product. The level of detail used in the specification of each item does not necessarily concern to the technology intrinsic nature or to its advancement state of innovation; it could simply concern to the centrality of the product with regard to the industry product definition. That is, the more the product is close to the core business of the industry, the more it is expected to be detailing described in the classification. This classification, differently from the functional one, is "items driven": the categories are not a priori stated, but are settled following the product configuration in the list.

Table 3 Automa s.p.a. merchandise portfolio

01.02.05.01.00.00.00.00	extrusion blow moulding machines
01.02.05.01.01.00.00.00	from 0 to 100 cu cm
01.02.05.01.02.00.00.00	>100 cu cm to 1 l
01.02.05.01.03.00.00.00	>1 I to 5 l
01.02.05.01.04.00.00.00	>5 I to 10 l
01.02.05.01.05.00.00.00	>10 I to 30 l
01.02.05.01.06.00.00.00	>30 I to 120 l
01.02.05.01.07.00.00.00	>120 l
01.02.05.03.00.00.00.00	injection blow moulding machines
01.02.05.03.01.00.00.00	from 0 to 100 cu cm
01.02.05.03.02.00.00.00	>100 cu cm to 1 l
01.02.05.04.00.00.00.00	injection stretch blow moulding machines
01.02.05.04.01.00.00.00	from 0 to 100 cu cm
01.02.05.04.02.00.00.00	>100 cu cm to 1 l
01.02.05.04.03.00.00.00	>1 I

As said before, different product market segmentations give rise to different firms "diversification patterns", in terms of number of roles played by each firm.

Consider, as example, the case of the firm Automa s.p.a., which is an ASSOCOMAPLAST member, and that - according to the merchandise portfolio present on ASSOCOMAPLAST's web site - offers 15 items, as we can see in the following Table 3.

The first column of Table 3 shows the eighth-digit codes which identify each of the 15 items produced by Automa s.p.a. According to these codes, Automa occupies one single technological segment at the first level of aggregation (01; first digit of the code), at the second (01.02; first two digits of the code) and at the third level of aggregation (01.02.05; first three digits). At the forth level of aggregation Automa s.p.a. occupies three technological segments (01.02.05.01; 01.02.05.03; 01.02.05.04); while from the fifth to the eighth levels of aggregation, it occupies 15 technological segments.

According to the functional classification, Automa occupies one functional segment at the first level of aggregation (all the 15 items belong to the category of machinery that process *plastic*), one functional segment at the second level of aggregation (all the 15 items belong to the category of *processing* plants), one functional segment at the third level of aggregation (all the 15 items belong to the category of *machinery*), one functional segment at the forth level of aggregation (all the 15 items belong to the category of the *blow moulding* machines) and two functional segment at the fifth level of aggregation (8 items belong to the category of the *extrusion* blow moulding machines; 7 items belong to the category of the *injection* blow moulding machines).

Hence, Automa s.p.a. exhibits various roles, both among technological segments and

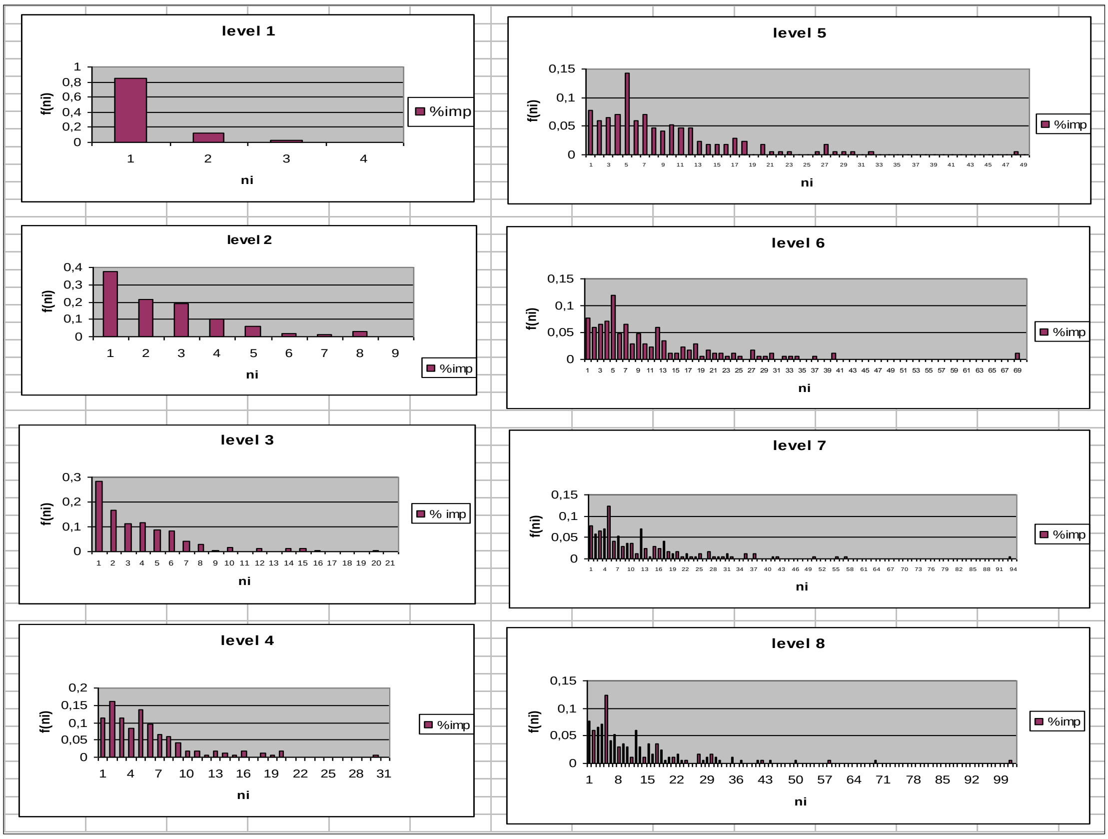

Figure 1. Firm role distributions in correspondence of, differently aggregated, technological market segmentations.

functional segments, in correspondence of different specification levels. Which of the previous roles hypothetically played by Automa s.p.a. is the most proper to describe the Automa s.p.a. real diversification strategy?

I have explored this sort of question at the industry level.

The following Figure 1 shows the distributions of the number of roles that the 169 Italian plastic and rubber processing machinery builders play in correspondence to each of the eight, differently aggregated, technological segmentations of the product market [where the product market consists in the whole ASSOCOMAPLAST product list, composed by 363 items].

Likewise, Figure 2 shows the distributions of the number of roles played by the 169 firms in correspondence to each of the five differently aggregated functional segmentations of the product market. Being nt_i and nf_i the number of, respectively, technological and functional segments occupable by a firm at the i^{th} level of specification; and being $f(nt_i)$ and $f(nf_i)$ the probability that a firm occupies nt_i technological segments and nf_i functional segments, respectively; in the following graphics (Figure 1 and 2)

I illustrate the distributions of the number of roles [$f(nt_i)$ and $f(nf_i)$] that the Italian plastic and rubber processing machinery builders play respectively among technological segments nt_i [Figure 1] and functional segments nf_i [Figure 2] in correspondence of each level of aggregation *i*.

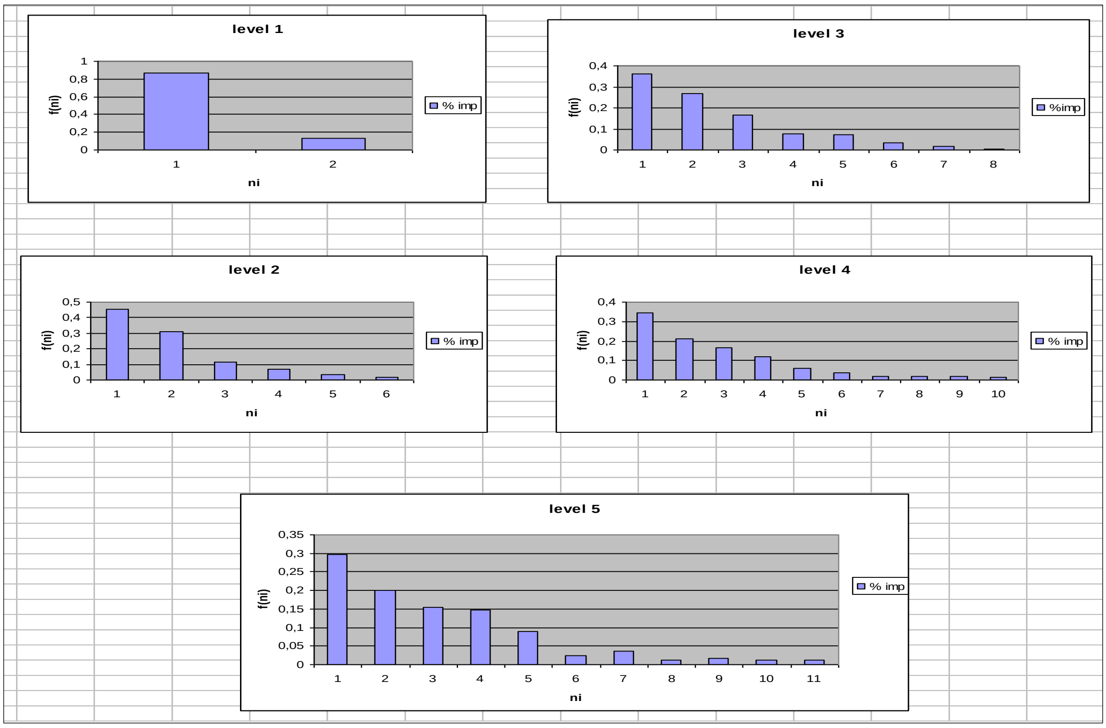

Figure 2. Firm role distributions in correspondence of, differently aggregated, functional segmentations.

As you can infer from the graphics above, and as expected, by modifying the criteria and the aggregation levels of the product market segmentations , the distribution of the number of firms' roles (measured by the number of segments simultaneously occupied by the firms) changes accordingly.

Hence, I aim at identifying which one of the 13 firms' roles distributions (eight distributions in correspondence of the technological segmentations, and five distributions in correspondence of the functional ones) mostly enrich our understanding of the diversification strategies adopted by plastic processing machinery suppliers, and, consequently, which product market segmentation is most informative on the firms' fundamental diversification criteria.

I compare the empirical firm roles distributions with their theoretical counterparts, in correspondence of each of the 13 market segmentations, by imposing the coincidence of the two classes of distributions at the lowest levels of aggregation (in order to guarantee the "correspondence" between theoretical and empirical firms role distributions). In the following Table 4 and Table 5 you can see the detail of the empirical firm role distributions in correspondence of the lowest levels of aggregation of, respectively, the technological and functional market segmentations [the same that are represented in Figure 1 (level 8), and Figure 2 (level 5), respectively].

Table 4. Empirical firms roles distribution in correspondence of the lowest levels of aggregation in the technological market segmentation.

n roles	n firms	n roles	n firms
1	13	21	2
2	10	22	3
3	11	23	1
4	12	24	1
5	21	27	3
6	7	28	1
7	9	29	2
8	5	30	3
9	6	31	2
10	5	32	1
11	2	35	2
12	10	37	1
13	5	41	1
14	2	42	1
15	6	44	1
16	3	50	1
17	6	58	1
18	4	69	1
19	1	101	1
20	2		

Table 5. Empirical firms roles distribution in correspondence of the lowest levels of aggregation in the functional market segmentation

n roles	n firms
1	50
2	34
3	26
4	25
5	15
6	4
7	6
8	2
9	3
10	2
11	2

According to Table 4 at the eighth aggregation level of the technologically segmented product market, 13 firms play one single role, 10 firms play two roles, and so on till the (single) firm that plays 101 roles (which means that one firm occupy simultaneously 101 technological segments). Similarly, according to Table 5, at the fifth aggregation level of the functionally segmented product market, 50 firms play one role, 34 firms play two roles, and so on till the 2 firms that play 11 roles.

While the theoretical distributions of the number of roles (played by the firms at the lowest levels of aggregation of the two market segmentations) do replicate the empirical "correspondent" distributions of the number of roles, they do not replicate the identity of the roles played by the firms. In other words, at the lowest levels of aggregation, what are exactly replicated are the distributions of the number of segments simultaneously captured by the firms in the two segmentations, but not the identity of the segments simultaneously occupied, which are instead randomly allocated among all the segments theoretically occupable. After that, at higher aggregation levels, the theoretical firm role distributions are obtained by grouping backward, according to the hierarchical branching paths, the segments simultaneously captured at the right lower levels of aggregation.

I define a "simulation process" the following sequence of two operations: the first operation consists in randomly allocating the identity of the roles played by the firms at the lowest level of aggregation; while the second consists in aggregating the firms roles at levels of aggregation higher than the lowest by following backward the branching path of the two market segmentations. By repeating this "simulation process" a sufficient number of times (25000) so as to reach convergences values, I obtain the (simulated) theoretical firms' roles distributions. In particular, each single "simulation process" converges to two sort of results: the first result consists in the number of roles played by the firms in correspondence of each aggregation level higher than the lowest, conditioned to the number of roles played at the lowest aggregation level; while the second result consists in the standard deviation which characterised the first class of results in comparison with their mean values (calculated on 25000 simulation processes). By weighing (multiplying) this two classes of convergence values - calculated in correspondence of each role that firms empirically play at the lowest level of the two market segmentation (see first columns of Table 4 and Table 5) - with the firm role distribution empirically observable at the lowest level of aggregation (see second columns of Table 4 and Table 5) and then by cumulating these results in correspondence of each aggregation level of the two segmentations, I obtain two classes of results. The first consists in the expected values of the theoretical firm roles distribution, in correspondence of each aggregation level of the technological (see Table 6, in Appendix) and functional (see Table 7, in Appendix) segmentation. The second consists in the expected asymptotic standard deviations of the theoretical firm role distributions, in correspondence of each aggregation level of the technological (see Table 8, in Appendix) and functional (see Table 9, in Appendix) segmentation.

By confronting the theoretical and empirical firms role distributions, I aim at evaluating the possible presence of any significant

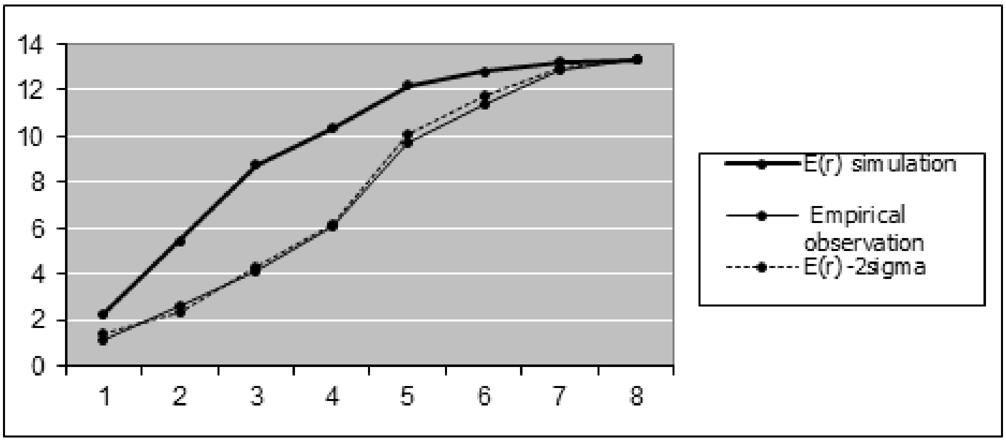

Figure3 Empirical and theoretical patterns of diversification in correspondence of technological segmentations.

discrepancy between the two classes of distributions, in order to recognize both the segmentation criterion and the aggregation level which most clearly reveals about the firms main diversification drivers.

In fact, the higher the discrepancy between the empirically observed distribution of the number of firms roles and its theoretical version, the stronger the evidence of some sort of synergies exploitation.

I assume such discrepancy being significant whenever it is bigger than twice the asymptotic standard deviations of the theoretical firm role distributions (2σ), see Table 10 and Table 11 in Appendix.

By observing the following Figure 3 e Figure 4, it is possible to state that - as expected - the empirical firm role distributions are more concentrate that the theoretical ones in correspondence of every aggregation level; even if they are *significantly* more concentrated almost exclusively in correspondence of the technological segmentations.

Figure 3 shows the comparison between the expected values of the empirical (thin continuous line) and the theoretical firm role distributions (thick continuous line) in correspondence of the eight, differently aggregated, technological market segmentations.

By comparing the $E(r_t)$-2 σ_t (hatched line) with $E(R_t)$ (thin continuous line) it emerges that, almost at every level of aggregation of the technological market segmentations, there exists some evidence of the significant discrepancy between theoretical and empirical firms roles distributions.

It means that there is a strong empirical evidence of the exploitation of technological synergies by the Italian plastic and rubber processing machinery builders.

In particular, given that the maximum discrepancy emerges in correspondence of the fifth aggregation level, it means that they exploit specific and deep technological synergies in their diversification choices.

The following Figure 4 shows the comparison between the expected values of the empirical (thin continuous line) and the theoretical firm role distributions (thick continuous line) in correspondence of the five, differently aggregated, functional market segmentations.

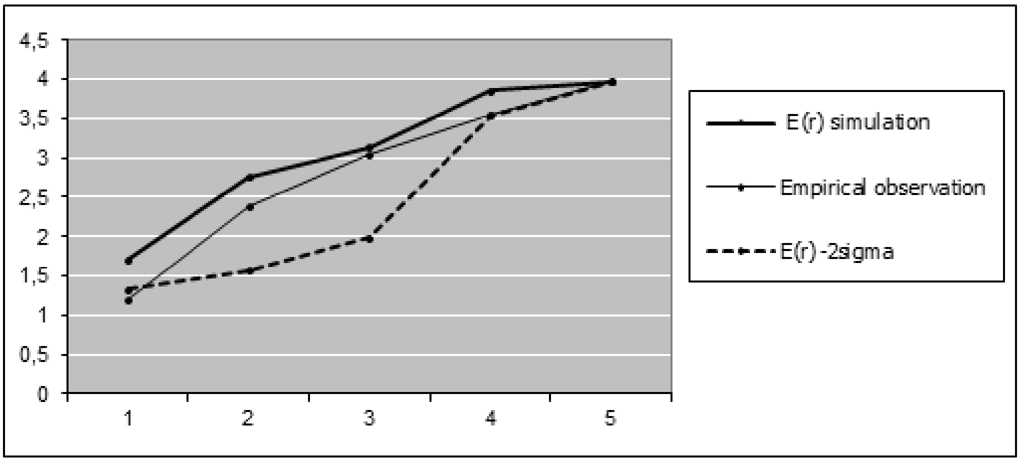

Figure 4 Empirical and theoretical patterns of diversification in correspondence of functional segmentations.

From the comparison between $E(r_f)$-2 σ_f (hatched line) and $E(R_f)$ (thin continuous line) it emerges that, at every aggregation level of the functional market segmentation a part from the first, it is not observable any significant discrepancy between the theoretical and empirical distributions of the number of firms roles. It means that there is not a strong evidence of the exploitation of functional synergies by the Italian plastic and rubber processing machinery builders.

These results indicate that the diversification degree of the Italian plastic and rubber processing machinery builders is properly measurable by counting the number of segments that they occupy at the fifth aggregation level of the technological segmentation. Furthermore, these empirical evidences suggest that in this industry technological forces play a more fundamental role than functional ones in the choice of diversification.

This corroborates with strong, if localised, empirical evidence the findings of those branches of the economic literature that have emphasized the importance of technological factors in the domain of business portfolio decisions.

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APPENDIX

Theoretical firms' roles distributions

Table 1. Expected values [E($r_{t,i}$)] of the theoretical firms' roles distributions*, in correspondence of, differently aggregated, technological market segmentations. [I= level of aggregation].*

I	I	II	III	IV	V	VI	VII	VIII
E($r_{t,i}$)	2.301509	5.434899	8.76838	10.3647	12.22542	12.81956	13.22323	13.32692

Table 2. Expected values [E($r_{f,i}$)] of the theoretical firms' roles distributions, in correspondence of, differently aggregated, functional market segmentations. [I= level of aggregation].

I	I	II	III	IV	V
E($r_{f,i}$)	0.028599	3.629748	4.033372	1.479635	0

Table 3. Expected asymptotic standard deviations E($\sigma_{t,i}$) of the theoretical firms' roles distributions, in correspondence of, differently aggregated, technological market segmentations. [I= level of aggregation].

I	I	II	III	IV	V	VI	VII	VIII
E(σt,i)	0.458557	1.521241	2.211816	2.117417	1.051688	0.51124	0.109549	0

Table 4. Expected asymptotic standard deviations E($\sigma_{f,i}$) of the theoretical firms' roles distributions, in correspondence of, differently aggregated, functional market segmentations. [I= level of aggregation].

I	I	II	III	IV	V
E(σf,i)	0.187135	0.595962	0.571586	0.155327	0

Table 5. $E(r_{t,i})$-$2\sigma_{t,i}$ of the theoretical firms' roles distributions in correspondence of, differently aggregated, technological market segmentations. [I= level of aggregation].

I	I	II	III	IV	V	VI	VII	VIII
E(rt,i)-2 σt,i	1.384395	2.392417	4.344748	6.129865	10.12205	11.79708	13.00414	13.32692

Table 6. $E(r_{f,i})$-$2\sigma_{f,I}$ of the theoretical firms' roles distributions in correspondence of, differently aggregated, functional market segmentations. [I= level of aggregation].

I	I	II	III	IV	V
$E(r_{f,i})$-2 $\sigma_{t,i}$	1.335214	1.57159314	1.9924752	3.54259795	3.9663866

Observed firms' roles distributions

Table 7. Expected values $E(R_{t,i})$ of the empirically observed firms' roles distributions, in correspondence of, differently aggregated, technological market segmentations. [I= level of aggregation].

I	I	II	III	IV	V	VI	VII	VIII
$E(R_{t,i})$	1.185897	2.621795	4.096154	6.115385	9.679487	11.4359	12.90385	13.32692

Table 8. Expected values $E(R_{f,i})$ of the empirically observed firms' roles distributions, in correspondence of, differently aggregated, functional market segmentations. [I= level of aggregation].

I	**I**	**II**	**III**	**IV**	**V**
$E(R_{f,i})$	1.193277	2.386555	3.042017	3.546218	3.966387

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