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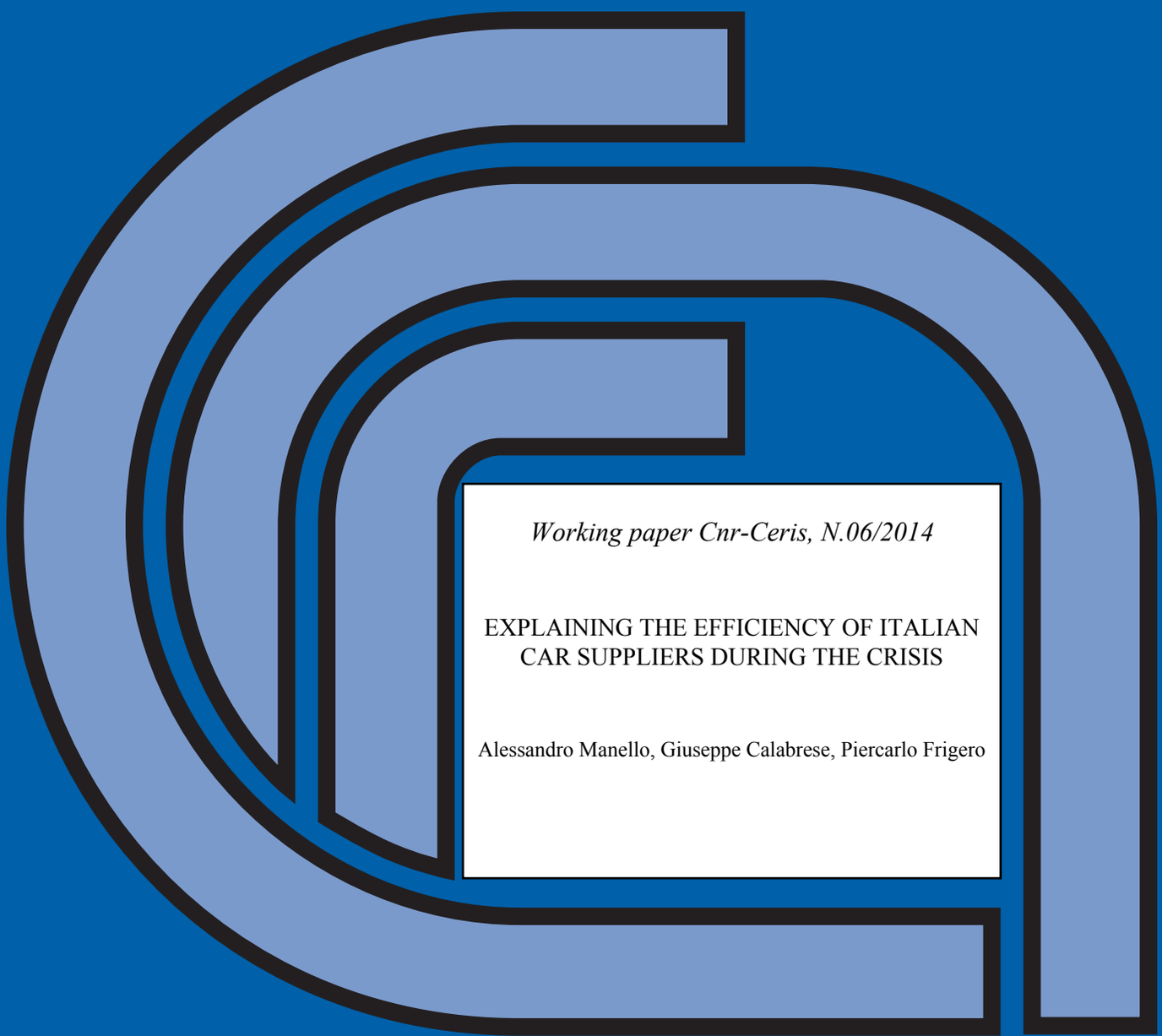

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EXPLAINING THE EFFICIENCY OF ITALIAN CAR SUPPLIERS DURING THE CRISIS

Alessandro Manello, Giuseppe Calabrese, Piercarlo Frigero

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Explaining the efficiency of Italian car suppliers during the crisis*

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ABSTRACT: This empirical study, focused on the Italian automotive sector during the recent international crisis, detects technical performance of firms using Data Envelopment Analysis. We pay specific attention to the role along the supply chain, to size and to vertical structure of firms. In particular, this study highlights how the recent crisis stimulates a deep process of re-organization, re-location and re-thinking of firms' position along the value chain but, in particular, the crisis stresses the pre-existing heterogeneity among firms. The technical frontier is driven by firms able to contribute to the technology, which represents essential link of the automotive value chain. Those firms are large, vertically disintegrated and operate in metals, plastic or machinery.

Keywords: Supply chain, Vertical integration, Data Envelopment Analysis, automotive sector.

JEL Codes: L22, L25, L62, O14

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* This paper is an advanced version of that presented at the Gerpisa 2013 conference in Paris, while it represents a preliminary version of that presented the SIEPI 2014 workshop in Naples.

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CONTENTS

1. INTRODUCTION: DEA AS A TOOL IN A SUPPLY CHAIN ANALYSIS

During the last decade, the increasing complexity production process and the increasing possibilities of integration among firms and products, favour the development of the so called Global Value Chain (GVC). This concept is mainly based on the idea of the so called modular production network as a form of industrial organization in high of medium tech industry, an idea that can be partially applied to the automotive sector. In fact, automotive industry take some important characters of modular network even if important aspect also of the captive network can be identified. An investigation of the firms' positions along those GVC gives important information of the main point of strength and of weakness of an economic system, because the core of each economy are always its firm. Therefore, starting from the differences between firms, studied in the context of their productive processes, can be an important indicator of the global condition of an economic system. Considering the competitiveness of countries, the role of their firms in the GVC are becoming one of the main indicators for the state of the economy. The case of Italy is emblematic in that sense: low growth rate, an increasing number of firms which decide to de-localize productions. In the automotive sector those evidence are particularly dramatic, with the "local champion", FIAT, involved in deep restructuring process and a strong integration with the American partner Chrisler. In this context the issue of becoming important nodes along the GVC is more than a pure opportunity, but it is essential for their survival.

The Italian automotive sector is characterised by a large number of small and medium firms, as well by local plants of large multinationals, both localized near production plants of the national champion. However, during the last decade, both the kind of firms have to rethink their role in order to the new Italian and European automotive supply chain.

Our study is focused on the important task of technical efficiency along the Italian automotive supply chain, with particular attention on the position of firms along that chain and on their choice around vertical integration and outsourcing. We adopt the Data Envelopment Analysis (DEA) for the measurement of technical or allocative efficiency and it is one of the first applications of efficiency model as a tool in the supply chain analysis.

To discuss this topic there are two main starting points: the theory of vertical integration and the study of differences between firms, which may be considered structural character of an industry. The nature of output produced and the degree of vertical integration show the position along the graph which describes the supply chain, with activities as nodes, and ties as relations between suppliers. In DEA applications, the cloud of points in a n – dimensional space may be analysed to verify the existence of clusters according to the roles in this particular type of network.

We can model these systems starting from a succession of tiers around a big firm projecting the final product and distributing the orders to its suppliers, each of which buy from firms of a subsequent level till the end of

the chain. To do so, we briefly discuss several types of supply chains which are useful to analyse firms diversity, and a taxonomy of roles inspired by the theory of networks.

In particular, our aim is to investigate if automotive firms in particular position along the supply chain show an higher technical efficiency than others or if something similar is valid for the degree of vertical integration. Moreover, we try to check if the different positions of the firm in relation to the efficient DEA frontier are distributed according to their roles along the supply chain or in relation with the degree of vertical integration. Finally, to summarize the main results, we adopt one of the most modern econometric techniques to identify the determinants of obtained technical efficiency scores.

The remainder of the paper is organized as follow. The section 2 briefly review the relevant literature, section 3 describes the DEA model adopted, while section 4 presents the dataset. Section 5 shows our main results and some general considerations conclude the work.

2. LITERATURE REVIEW: VALUE CHAINS, PRODUCTIVITY AND VERTICAL INTEGRATION

A supply chain is always a hierarchical set of firms linked at different level of a productive process ending with a final product. In vertical links (relation between suppliers of different layers) and even in horizontal links (relation between suppliers on the same layer) market power is evenly distributed. But, beyond the traditional, focused on pricing over marginal cost, what matters is the ability to influence technology and product characters, starting from the projected final results, but involving also intermediate component which influence performances and quality appreciated by the customers. So our main interest reside in the analysis of three type of chain (defined by governance): "captive: when the ability to codify, in the form of detailed instructions, and the complexity of product specifications are both high, but supplier capabilities are low; relational: when product specifications cannot be codified, transactions are complex, and supplier capabilities are high; modular: when the ability to codify specifications extends to complex products, and suppliers have the competence to supply full packages and modules" (Gereffi et al., 2005).

Using these criteria it is possible to connect the shape of the supply chain with firms performances, through vertical integration and outsourcing in search of a model of organization which could enhance the productivity defined as the ratio between costumers' utility and total cost of inputs over the whole vertical integrated sector. The uneven distribution of market power explained by a set of variables starting from property rights, to assets specificity and idiosyncratic relations, is a typical field of the theories of the firm, but can be approximated by some profitability indexes.

Some suggestion resides in the model proposed by Van Assche (2005). He proposes the distinction between: ideal outsourcing (each supplier sells to a specific final firm); standardized outsourcing (the burden of customization of components falls on the buyer) and customized outsourcing (when the burden falls on the seller, which adopt flexible manufacturing equipment). Unfortunately it is not easy to collect information needed to clearly classify suppliers.

Focusing on efficiency and productivity, in the literature above all are discussed correlations between productivity and firm organization defined by vertical integration versus outsourcing. In the study Heshmati (2003) argue that vertical integration depends on outsourcing decision, and manufacturing firms increased productivity through the outsourcing of in-house services, aiming at of reducing labour cost and enhance flexibility. Owing to the slower technical change in the service sector, it results a higher rate of productivity growth eventually influencing the correlation between compared efficiencies. Following these hints, it's advisable to compare firms' efficiency with caution, because their position may depend on differences in the use of specific assets, and some resulting bias towards internal production. Girma and Görg (2004) found that in the chemical and in the engineering industries, outsourcing is positively related with labor productivity, while it does not seem to exert any influence on the productivity of plants in the electronics sector. The elasticity of labor productivity with respect to outsourcing is about three times higher in the engineering than in the chemicals sector. Furthermore, this productivity effect of outsourcing is more pronounced in the sample of foreign-owned establishments. Pieri and Zaninotto (2013) studying the Italian machine tool industry, found that that vertical integrated firms present a lower variance (and lower mean) of the inefficiency distribution, after having controlled for firm size, type of ownership, agglomeration economies and the economic cycle. Thus, vertical integrated firms are, ceteris paribus, more efficient in the industry under analysis than disintegrated firms. This results from a self-selection mechanism of more efficient firms to vertical integration which perhaps could be also interpreted as the result of a more detailed and stable set of strategies for the integrated firms. According to Federico (2012) there seems to be a productivity ordering by which foreign-integration firms are the most productive, and domestic-outsourcing firms are the least productive, but foreign-outsourcing firms are *less* productive than domestic-integration firms. This suggests a relatively high fixed cost of integration, which more than offsets the fixed cost of operating with foreign suppliers. A second result is that integration is preferred to outsourcing in headquarter-intensive industries, notably in capital-intensive industries. These findings also predict that the Italian manufacturing industry will show a greater preference for outsourcing over FDI than other EU countries' industries, given its smaller average firm size and its specialization in sectors with lower capital intensity. Agostino et al. (2012) performed an econometric investigation on a representative sample of 3904 Italian manufacturing firms and found that labour and TFP depends mainly on firm's ability measured in terms of exporting and innovating, and this challenges the tradizional view of position in supply chain determining performances. In all specifications of the regression model they use, the most capable suppliers (i.e., the ones exporting and carrying out both product and process innovation) show both labour productivity and total factor productivity that are not lower (and actually are higher) than other firms with a comparable level of capabilities. Instead, when firms with lower abilities are considered, a negative productivity gap emerges for supplier firms relative to non-supplier firms. This gap is

larger when firms are neither innovators nor exporters, and smaller when producers either innovate or export but not both.

Focusing on Italy, automotive suppliers located have been differently defined in the last three decades. In the '60s and '70s they were called "induced automotive activities" or, even better, "induced Fiat activities" to indicate a situation in which suppliers were dependent on Fiat. In the '80s and at the beginning of the '90s, the automotive suppliers were first defined as a "system", in order to stress structural interdependencies among all the firms in the supply chain, and recently as a 'technological automotive district" (Bianchi et al., 2001).

The defining changes come from the rooted and lasting relationship between Fiat and its native territory. In fact, around Fiat a widespread knowledge in design and engineering is risen from well known body-makers (from Bertone to Ghia) and car stylists (from Pinifarina to Giugiaro) to a plethora of small and micro firms that are unable to independently work for mentality but above all for economic reasons. A supply-chain that reproduced in the past, more or less, the same yields of Fiat.

Nowadays, the worries above all regard the entrepreneurial ability of Piedmont automotive suppliers to compete with the world-wide players without the traditional "filter" offered by Fiat

In 2012 the Italian supply chain generated a turnover of 38 billion euro and employed a total of 179,000 workers (Anfia, 2013). The industry is still characterized by small size and high production fragmentation: small firms with less than 50 employees are about 75% of the total (STEP, 2012). Of course, this might be a weakness, because small firms are generally less innovative than medium-large firms. Production is concentrated in a few areas, with just under 40% of manufacturers located in Piedmont.

The level of diversification towards other sectors is quite low: on the whole, 80% of sales are made to the automotive sector (STEP, 2011) and 35% to the sub-suppliers. Nevertheless, diversification changes across the various regions: it is higher in Emilia-Romagna, where firms focus not only on the automotive but also on the motorcycle and agricultural vehicle sectors, as well as other sectors (Bardi, Calabrese; 2007), while it is lower among Piedmont companies, mainly manufacturing for the FIAT Group (Enrietti et al., 2007). The automotive sector's dependence on FIAT is still high, about 55%, but it is decreasing.

The distribution of Italian automotive supply chain according to its main areas of operation is mainly focused on providers of materials and minor mechanical works (Sub-suppliers, 52.0%) and manufactures of automotive parts (Components, 30.0) and less on manufactures of automotive modules and systems (6.0%) and providers of automotive design and engineering services (12.0).

Most of the module and system suppliers are multinationals which have purchased plants from large domestic suppliers and adapted them to the tiered production system launched by FIAT Auto during the 1990s (Enrietti, 1997; Rolfo and Vitali, 2001). Nowadays, their dependence on FIAT Auto has decreased and they are selling to other carmakers through their affiliated companies; consequently, many module and system suppliers seem to have downsized or closed their local R&D centres, as research is carried out at their headquarters.

The component manufacturers and sub-suppliers have a tendency to operate in a context of incremental innovation. The analysis refers to mature technologies, i.e. cases in which the innovation process proceeds over time along a logistic curve. For these firms innovation is not a structured activity; rather, it is incremental, occurring on a daily basis and involving all aspects of the company. Nevertheless, the technological sophistication of component suppliers has constantly increased in order to meet the needs of their automotive customers. In the past they only provided generic materials, whereas they now tend to produce highly specialised products.

Engineering & design firms are concentrated in Piedmont (more than 60%), but only few of them, such as Pininfarina, Giugiaro, and Bertone, are known worldwide. However, Piedmont's automotive cluster includes a large number of firms, even though most of them are very small and only a dozen have more than 100 employees (Calabrese, 2010).

3. METHODOLOGY

3.1 The technical efficiency model

In the present paper we adopt a fully non parametric Data Envelopment Analysis approach to compute efficiency scores of a large sample of Italian firms operating in the automotive industry.

The main advantage of using DEA is that it does not require specifying a form for the technology representing the production process and then no assumptions have to be done on the shape of the production frontier. Moreover, DEA allows computing a simple inefficiency measure also in the case of multi-outputs and multi-inputs underlying technology: the frontier is directly derived by data and all firms in the sample are evaluated in term of it through input or output distance functions.

The main disadvantage of this deterministic approach lie in the absence of error component: a frontier is estimated and all the departure from that is detected as inefficiency without considering the possibility of stochastic disturbance. DEA methodology has been widely used, from the 80's, to assign technical efficiency score, scores that could be analysed using non-parametric techniques. For a detailed treatment of DEA see Färe et al. (1994).

The framework can be input or output oriented. The input-oriented framework, based on the input requirement set and its efficient boundary, aims at reducing the input amounts by as much as possible while keeping at least the present output levels. In this approach output levels remain unchanged and input quantities are reduced proportionately till the frontier is reached and generally this is the orientation adopted by the decision maker that can control inputs but not outputs at all. Alternatively, the output-oriented framework looks at maximizing output levels under at most the present input consumption. This approach is also known as the "output-augmenting" approach, because it holds the input bundle unchanged and expands the output level till the frontier is reached (Daraio and Simar, 2007). On a base of previous considerations, output-oriented framework has been used here, assuming constant returns to scale (CRS) on the basis of Charnes *et al.* (1978) model. Technical efficiency scores TE, are then computed by solving, for each firms in the sample, the following linear problem:

$$TE = \text{Max } \vartheta$$
$$\text{st}: \vartheta y_0 - Y\lambda \leq 0 \quad (1)$$
$$-x_0 + X\lambda \leq 0$$
$$\lambda \geq 0$$

Where θ is a scalar > 1, λ is a vector of nx1 weights allowing convex combination of inputs and outputs, Y is an output matrix, X is an inputs matrix. Further, θ-1 presents the output proportional feasible increment, maintaining constant input level. Obtained TE take the unity value if no expansion of outputs are technically feasible, then the firm is on the best practice frontier. A value greater than one represent the possibility of increasing outputs, in this case the firm is inefficient in combining inputs.

3.2 Analising efficiency results with the truncated regression model

Efficiency scores, estimated using deterministic techniques, can be considered as a proxy of the technological/organisational level of efficiency, but their distribution cannot be analysed using standard econometric techniques. The investigation of those aspects influencing the level of technical efficiency is a controversial point in the productivity literature and only some recent contribution suggest valuable techniques to analyse those outcome. A standard approach should be based on a regression analysis, where the effect of single variables could be isolated and their significance should be inferred using standard statistical tools. However, the particular distribution of the scores, truncated at 1 and non-normally distributed, make the regression approach (and its variants) not consistent. In particular, standard OSL estimates cannot lead to the true parameter as it is proved by Simar and Wilson (2007). To solve the problem Simar and Wilson (2007), after identifying the complex structure for residuals in a regression model which explain efficiency, show how the truncated regression model can lead to unbiased estimates compared to OLS and Tobit approach.

Therefore, we adopt the truncated regression model, including our variables of interest (VI and position along the chain), together with additional control variable on which managers cannot have direct control, at least in the short run:

$$TE_i = \beta' w_i + \alpha' z_i + \varepsilon_i \geq 1 \quad (2)$$

where $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$ before truncation, TE_i are the estimated technical efficiency scores by DEA, β' are the parameters to compute, w_i are our variable of interest representing vertical integration and the position of the firm along the supply chain. The matrix z_i contains control variables such as an indication of size, sectoral dummies, geographical dummies, ε_i is the error term and σ_ε is the error variance (Barros and Dieke, 2008).

4. DATA

We collect data to draw a comprehensive picture of the Italian automotive supply chain by merging different databases coming from previous empirical investigations made by Italian scholars (STEP, several years; Bardi and Garibaldo 2005; Morsa, Pirone, 2010; Zirpoli, Stocchetti, Scattola, 2012; Enrietti, 2007; Calabrese and Erbetta, 2005).

The result can be considered an accurate representation of the total population of the Italian automotive supply chain. The sample includes 4,207 firms and it is more

comprehensive than other surveys (STEP, 2012). Differences mainly consist in how the supply chain[2] is defined and which types of companies, as to their liability, are considered. The sample is made up of 72.6% limited-liability companies and 27.4% unlimited-liability companies. The impossibility to cross-check the sample with the database of the Italian Network of Chambers of Commerce, in which all the companies are listed, caused the analysis to be restricted to the limited-liability companies included in the Aida[3] database of Bureau van Dijk. This limitation reduced the sample to around 2000 companies, but its spatial representativeness was preserved, since regional differences between the first and the second sample are minimal. Concerning the final sample, the first methodological step was to consider only firms with complete balance sheet data for both 2007 and 2011 observation years: this limit reduce the sample to 1641 firms. Furthermore, we focus our attention on firms operating in the automotive supply chain, then we exclude large assemblers such as Fiat, but we consider its First, Second and Third Tier suppliers.

Due to the strong impact of the recent crisis on the sector, we limit the analysis to firms which are able to survive during the crisis, then only firms observable in 2007 and 2011.

First of all we present the distribution according to the role in the supply chain and the size of the selected firms.

Table 1 reports the position of firms in the automotive supply chain and the average inputs-outputs data for each group. Firms operating in metals and components are more numerous and especially in metals we can expect a larger proportion of SMEs as suggested by average inputs and outputs.

We can observe in general a prevalence of small business in all these rought supply chain nodes, with the average firms caracterised by limited assets (metal and plastic). However, after a deeper analysis of firms' size based on the European classification reported in table 2, the conclusion on the prevalence of small businesses in certain sector can be re-formulated.

In particular, the cumlative share of small enterprises (micro and small business) around 65% of the total sample, seems to be higher considering only components and design (for both 70%).

The issue of a different presence of small and micro firms in certain activities is more deeply discussed in table 2, where firms' size and prevalent activities are jointly analysed.

We compute the Adelman (1955) index of vertical integration, using the reverse of the external cost over total cost ratio and we divide our sample of firms according to 4 categories of different verticalization strategy. Using the quartiles of the computed index as thresholds, we identify firms with a high vertical integration (disintegration) and those with an intermediate integration (disintegration). Micro and small firms show a higher propensity to make internally while more large firms tend to outsource processes. Therefore, we can conclude that vertical integration prevails in small business while de-verticalization is a character of medium and big firms.

[2] The automotive supply chain can be understood as including only companies whose core business is directly connected to car products or extended to companies belonging to functional sectors too.

[3] The Aida database mainly contains financial data on limited companies. Companies which are no longer active are included as well.

Table 1. Composition of the supply chain and average inputs - outputs values 2011

Sectors	N. of firms	Inputs			Output
		Technical assets (000s €)	Intermediate goods (000s €)	Labor costs (000s of €)	Production (000s €)
Metal	134	2,899	13,802	3,715	24,214
Machinery	422	2,800	7,546	2,483	14,829
Plastic and rubber	112	4,065	14,537	4,276	25,930
Components	775	3,716	14,101	3,816	23,743
Electronic	113	4,960	20,816	5,554	35,027
Design and others	53	8,355	8,214	4,874	23,450
Total sample	1,609	4,206	11,202	3,622	20,033

Source: Calabrese and Manello (2014)

Table 2. Distribution of the sample accodring to supply chain nodes and size (2007)

Firm's size	Supply chain nodes						
	Components	Electronic	Machinery	Metal	Plastic and rubber	Design and engineering	Total sample
Micro	30%	31%	13%	21%	19%	26%	26%
Small	40%	30%	49%	44%	41%	47%	41%
Medium	20%	24%	23%	27%	31%	19%	23%
Medium Large	8%	12%	14%	7%	7%	7%	8%
Large	2%	3%	1%	0%	1%	2%	1%

Source: Calabrese and Manello (2014)

5. RESULTS

Linear problems in the form of equation 1 are solved for each firm and for each year (2007-2011) using R and routines in the package FEAR. Outliers are detected using the routine in the package FEAR and in particular using the Wilson (1993) outlier detection method, the presence of some "strange" financial situations cannot be excluded. The estimated efficiency scores come from a unique frontier, where all firms involved in the automotive sector have been considered to adopt the same technology.

Of course this assumption seems too restrictive in some cases, mainly when the real production process underling some particular components are a little bit far one to another. For this reason results must be interpreted with care, due to the nature of DEA that is born to compare small sample of homogenous firms producing physical quantity of homogenous outputs and implying physical quantity of homogenous inputs.

Table 3: efficiency scores by activity along the supply chain

	DEA scores 2007	DEA scores 2011
Metal	2.326	3.340
Machinery	2.081	2.753
Plastic and rubber	2.068	2.786
Components	2.529	4.641
Electronic	2.648	3.156
Design and others	2.847	3.851

Source: Calabrese and Manello (2014)

For these reasons the levels of inefficiency must to be interpreted with care in our case based on balance sheet data, and relative comparison seems preferable to absolute conclusions.

5.1 Efficiency results along the supply chain, size and strategies

The technical efficiency performances are strongly correlated whit the position of the firms along the supply chain. Moreover, the level of power along the chain remains one of the most important factor reflecting the technological level of firm's production activities. The investigation of strengthen and weakness along the different phases is one of the most important but difficult task in the modern industrial organisation. This topic goes beyond the objective of our study in which we only try to describe the distribution of technical efficiency, computed through DEA, for 6 of the main activities that characterise the automotive sector.

Results from the solution of linear program (1) are reported, as average over each categories, in table 3.

The effects of the recent crisis have been particularly strong in the automotive sector, and they are evident in the table 3 from the comparison of the second and third column. The table suggests that the crisis stresses differences among firms and extreme positions on both sides emerge clearly. From the one hand, highly efficient firms show good ability in facing the new challenges from the international crisis of the automotive sectors by diversifying their customers and their activities. From the other hand marginal firms does not have the internal resources to play the same game. The result is an increasing heterogeneity within the same sector, with two group of firms following two different growth and efficiency path.

However, some additional conclusion can be drawn considering the chain perspective, what emerges is that firms operating in the Plastic & Rubber and Machinery are less inefficient in both periods, while Design and Engineering shows the worse performance in 2007 (2.847). Also electronic equipments producer are not so efficient in both years. Non parametric Kruskal-Wallis test confirms that the observed differences are statistically significant at 95 % level of confidence. Firms operating in the cars' components sector seems to pays the larger price from the rising of the crisis as it is underlined by the strong increasing of average inefficiency from 2007 to 2011. Indeed, firms operating in the components sector are heterogeneous: on the one hand very efficient firms are able to sell their products worldwide, to a plurality of big

Table 4: efficiency scores by firm size

	DEA scores 2007	DEA scores 2011
Micro	3.456	6.922
Small	2.307	3.332
Medium	1.739	2.325
Medium Large	1.870	1.859
Large	1.689	2.299

Source: Calabrese and Manello (2014)

Table 5: efficiency scores make or buy strategy

	DEA scores 2007	DEA scores 2011
Highly Deverticalized	1.525	2.204
Deverticalized	1.788	2.008
Integrated	2.064	2.238
Highly Integrated	2.559	3.247

Source: Calabrese and Manello (2014)

assemblers, producing highly technological products. Those actors remain competitive also during the recent crisis. On the other hand, marginal firms operate in the sector by producing marginal components using traditional technology. Those firms are not able to drive or develop technology and are more exposed to international competition, then to re-localization in low cost labour countries. During the recent crisis these firms pay the higher cost from the contraction of the demand from the local champion (FIAT) and they are not able to find other markets, with a consequent under utilisation of their production capacity that causes dramatic efficiency cut-offs.

This vision is partially confirmed by looking at efficiency performance over size class of the firms, reported in table 4. Micro-firms are confirmed to be the most inefficient class, as it is suggested by the branch of literature underlining the technical limits of small dimension for scale economies and R&D investments. Medium firms seem to perform better than medium-large, while their efficiency is strongly higher than small firms. That evidence suggests a clear positive effect of size on efficiency which is particularly strong going from micro to small firms, with an average differential of 1.149 in term of efficiency scores. Also in this case, non parametric test have been run to confirm the statistical validity of the considered differences and they confirms differences among size class groups.

Large firms are the most efficient showing their superior ability of driving technology and saving resources thanks to scale economies, but they show difficulties during the crisis. Being large represents an advantage in term of technical efficiency, but during a period of crisis the rigidities due to the size overcome the advantage, as highlighted by the better performances of medium-large firms in 2011 (1.8 versus 2.2 in terms of average efficiency scores, medium large versus large

firms in 2011). However, we have to notice that the medium size performs very similarly to large firms to underline that the technical level of these two group of firms is very similar: the real jump is from micro-small firms to medium and large firms.

Finally, we investigate the role of vertical integration strategy of efficiency performance, by computing average efficiency scores over the quartile of the distribution of the Adelman index (results are reported in table 5).

If the level of vertical integration is neutral to the computed efficiency scores, their average value for the four identified groups will be similar. Kruskal-Wallis non parametric test confirms that the level of inefficiency changes significantly over the four identified groups.

The relationship between vertical integration and efficiency is clear: the higher the level of vertical integration the higher the level of inefficiency.

That evidence is substantially stable during the period of crisis. The only exception is represented by highly deverticalized firms, which during the crisis seems to suffer much than others. In conclusion, the crisis increases inefficiency without clear effect on make/buy strategies.

5.2 The effect of vertical integration on efficiency performances: a regression analysis

Following the teorethical section, we run 4 different truncated regressions, on the basis of the model reported in equation (5): 2 model for each observation year, including (excluding) regional dummies to control (not control) for specific geographical caracters. Results are reported in table 6. This approach allows to be more confident on the robusteness of results for what concerns the main empirical evidence in term of the magnitude of most important coefficients, their sign and their statistical significance.

At level of interpretation we remind that the dependent variable represents the inefficiency level for each firm, corrected through the boostrap phase, according to Simar and Wilson (2007).

Table 6. Truncated regressions results

	Dependent variable			
Independent variables	DEA scores 2007		DEA scores 2011	
Size	-0.257	-0.255	-0.815***	-0.878***
Highly Deverticalized	-0.167	-0.149	-0.667	-0.540***
Integrated	0.312**	0.350***	0.123	0.179
Highly Integrated	0.751*	0.849**	2.848*	3.101**
Electronic	0.261	0.175	-0.860	-1.104
Machinery	-0.414*	-0.415***	-1.116	-1.24
Metal	-0.635**	-0.584**	-1.432	-1.334
Plastic and rubber	-0.547**	-0.405***	-2.063	-1.171**
Design and engineering	-2.313	-2.202	-2.912	-2.722**
Constant	6.515**	6.303**	16.24***	17.403**
Geographical dummies	YES	NO	YES	NO

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The R package FEAR is employed for all the computations. Therefore, positive coefficients in the table 6 indicate that the regressor increase inefficiency, while negative coefficients show that the variable reduce the inefficiency level.

The traditional positive effect of size on technical efficiency is only evident in 2011, while before the crisis the higher utilisation of production capacity allows good performances also to smaller firms.

The higher vertical integration remains an important detrimental factor for efficiency also after isolating the role of size, given the higher level of vertical integration for small and micro firms. Finally, from the supply chain viewpoint, firms operating in metal and plastic are confirmed more efficient, with also firms operating in the metal sector.

6. CONCLUSIONS AND FINAL REMARKS

This study analyses large sample of Italian firms involved in different phase of the automotive industry, strongly influenced by the recent world crisis. We consider the last financial data before the crisis (2007) and the last available data (2011) to have a clear picture of the impact of the crisis. We compute the efficiency performance of each firm in each year and we complete the work by obtaining the total factor productivity for the period 2007-2011 and in most of the case we observe a contraction in the productivity levels. The result is not encouraging, but it is somehow expected: the crisis reduces the production volumes and it causes an under-utilization of production factor that can be quantified by the efficiency contraction. Moreover, we try to drawn a more precise picture of the situation by analyzing three different dimensions which can deeply influence the observed performances. First of all, we consider the prevalent activity done by each firm within the wide automotive industry: we identify 6 main activities and we observe that firms operating in machinery and rubber are more technically efficient, but they do not show superior productivity growth. Secondly, we investigate the issue of firm size and its relationship with efficiency, a controversial issue in the literature. We find evidence supporting the higher technical efficiency of large firms, due to the impact of scale economies, but during the crisis they seem to suffer much, probably for their lower flexibility.

Finally, the aspects related to the make or buy decision also deeply influence efficiency performances. We test the hypothesis that the level of vertical integration influence efficiency scores by dividing the sample in 4 groups using the quartile of the Adelman integration index. If the vertical structure was neutral to efficiency, we expect more or less the same level of efficiency in all the groups. However, inefficiency is considerably different across different level of vertical integration and also non-parametric tests confirms this intuition. A regression analysis, based on one of the most modern econometric technique substantially confirms previous expectation: more integrated firms are less efficient. Larger firm show better technical performance only during the crisis, underlining how during expansions also smaller firms are able to reach higher level of technical performances, while more difficulties arise when a contraction of the demand reduce production capacity utilization.

REFERENCES

Adelman M.A. (1955). Concept and Statistical Measurement of Vertical Integration, in Stigler G.J., ed., *Business Concentration and Price Policy*, Princeton, N.J.: Princeton University Press, pp.281-321.

Agostino M., Giunta A., Nugent J.B., Scalera D. and Trivieri F. (2012). Firm Productivity, organizational Choice and Global Value Chain, Orkestra Working Paper Series in Territorial Competitiveness Number 2011-R09(ENG) ISSN 1989-1288, Basque Institute of Competitiveness.

ANFIA, (2013). Quali prospettive per la Componentistica italiana nel contesto internazionale? Limiti e Opportunità, Torino 7 maggio.

Bardi A., Calabrese G. (2007). Spatial organisation and company performance: a comparison between two models in the motor vehicle industry, *International Journal of Automotive Technology and Management*, Vol. 7, N. 1, pp. 88-107.

Bardi A., Garibaldo F. (editors), (2005). Company Strategies And Organisational Evolution in the Automotive Sector: A Worldwide Perspective, Peter Lang Pub Inc.

Barros C.B, and Dieke P.U.C. (2008). Measuring the economic efficiency of airports: a Simar-Wilson methodology analysis, *Transportation Research Part E*, vol. 44, pp 1039-1051.

Bianchi R., Enrietti A. and Lanzetti R. (2001). The technological car district in Piedmont: definitions, dynamic, policy, *International Journal of Automotive Technology and Management*, Vol. 1 N. 4, 397-415.

Calabrese G. (2010) *La filiera dello stile e le politiche industriali per l'automotive in Piemonte e in Europa*, Franco Angeli, Milano.

Calabrese G. and Erbetta F. (2005). Outsourcing and firm performance: evidence from Italian automotive suppliers, *International Journal of Automotive Technology and Management*, Vol. 5, n. 4, pp. 461-479.

Calabrese G., Manello A. (2014). La filiera dell'automotive e il ruolo dei fornitori italiani, in *Evoluzione della grande impresa e catene globali del valore* (editor Zanetti G.), Genova, Fondazione Ansaldo Editore, pp. 237-289.

Charnes A., Cooper W. and Rhodes E. (1978). Measuring the Efficiency of Decision Making Units, *European Journal of Operational Research*, vol. 2, pp. 429-444.

Daraio C. and Simar L. (2007). *Advanced Robust and Nonparametric Methods in Efficiency Analysis: Methodology and Application*, Berlin, Springer.

Enrietti A., Lanzetti R. and Sanlorenzo L., (2007). La componentistica in movimento: le piccole-medie imprese Piemontesi negli anni della crisi Fiat, in *Il knowledge management come strumento di vantaggio competitivo: un confronto intersettoriale*, (editor Volpato G.), Venezia, Carocci, pp.159-189.

Enrietti A. (1997). "Il processo di selezione della componentistica auto piemontese", in *Quaderni di ricerca*, n. 26, Associazione IRES Lucia Morosini, Torino.

Färe R., Grosskopf S. and Lovell K.C.A. (1994). *Production Frontiers*, Cambridge, Cambridge University Press.

Federico S. (2012). Headquarter intensity and the choice between outsourcing versus integration at home or abroad, *Industrial*

and Corporate Change, vol. 21(6), pages 1337-1358.

Gereffi G., Humphrey and Sturgeon T. (2005). The governance of global value chains, *International Political Economy* 12:1 February: 78–104

Girma S. and Görg H. (2004). Outsourcing, Foreign Ownership, and Productivity: Evidence from UK Establishment-level Data, *Review of International Economics*, 12(5), 817–832.

Heshmati A., (2003). "Productivity growth, efficiency and outsourcing in manufacturing and service industries", *Journal of economic surveys* , vol. 17 n.1.

Manello A. (2012). Firm's efficiency and foreign ownership: evidence from Turin automotive cluster, *International Journal of Automotive Technology and Management*, Vol. 12, No.1, pp. 76 - 91.

Morsa G. and Pirone F. (2010). A motori spenti Rapporto sulla F.M.A. e l'industria dell'auto in provincia di Avellino, FIOM CGIL Avellino .

Pieri F. and Zaninotto E. (2013). Vertical integration and efficiency: an application to the Italian machine tool industry. *Small Business Economics*, 40(2), pp. 397-416.

Rolfo S. and Vitali G. (2001) *Dinamiche competitive e innovazione nel settore della componentistica auto*, Franco Angeli, Milano.

Simar L. and Wilson P.W. (2007). Estimation and Inference in Two-Stage, Semiparametric Models of Production Processes, *Journal of Econometrics*, 136, 1, pp. 31-64.

STEP (2010-2011-2012). Osservatorio sulla componentistica autoveicolare italiana.

Sturgeon T., Van Biesebroeck J. and Gereffi G. (2008). Value chains, networks and clusters: reframing the global automotive industry, *Journal of Economic Geography*, 8, 297-321.

Van Assche A. (2005). A Theory of Modular Production Networks, HEC Montreal September.

Wilson P. (1993). Detecting outliers in deterministic nonparametric frontier models with multiple outputs, *Journal of Business and Economic Statistics* 11, pp 319-313.

Zirpoli F., Stocchetti A., Scattola E., (2012). *The Crisis from a Supply Chain Perspective: the Case of the Italian Automotive Supply Chain*, Palgrave.

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