A two-stage efficiency analysis: An application to the Italian logistics firms

Ferrari, Claudio – Department of Economics, University of Genoa[1]

Migliardi, Andrea – Bank of Italy, Genoa

Tei, Alessio – Department of Economics, University of Genoa

Abstract

Logistics is becoming a major fundamental economic sector not only as an industry itself but mainly for its contribution to featuring firms' productivity. As argued by several reports, logistics enhances the productivity and the competitiveness for several manufacturing supply chains. The analysis of the efficiency trends of logistics providers – together with their main determinants – may be able to shed light on some relevant aspects that can improve the national industrial system competitiveness. Thus, the paper focuses on the Italian logistics market in order to better understand the distribution of the efficiency level within the logistics sector and its causes.

The analysis is based on a two-stage methodology aiming at (a) estimating the Italian logistics firms efficiency and (b) defining – and possibly measuring – some characteristics impacting on the efficiency level. For this aim we implement a non-parametric estimation (*Data Envelopment Analysis*) at the first stage and an econometric regression at the second stage, by using variables regarding each single firm of our sample. The input data, constituted by balance-sheet data, is drawn from the national accounting database of the Chambers of Commerce (i.e. Cebil-Cerved) for the period 2006-2012. According with our main results, size and geographical localization are two of the most impacting variables on the efficiency level of the Italian logistics providers.

JEL: R49; D22

[1] The views expressed in this paper are those of the authors and do not involve the responsibility of the Bank of Italy and of the University of Genoa.

1. Introduction

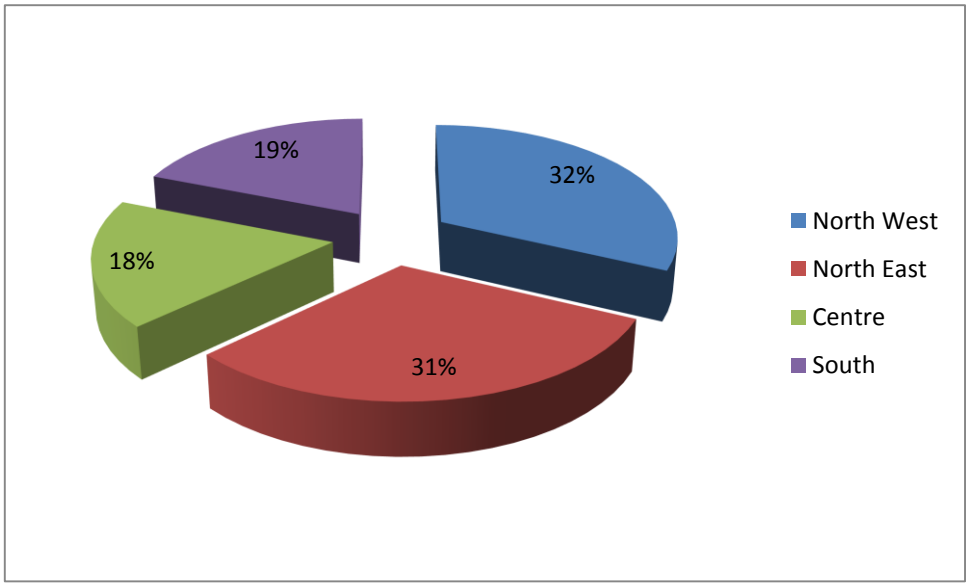
Logistics consists in the "process of planning, implementing, and controlling the efficient, cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from a point of origin to the point of consumption for the purpose of meeting customer requirements" (Council of Logistic Management, 1998). The relationship between logistics and production is quite strict because logistics not only acts as a specific industry but also as functional part of other industrial sectors able to add value to production outputs, encountering the changing market needs and assuring that goods are given where necessary, with an acceptable and efficient distribution (e.g. Fugato et al., 2008).

All the goods that we daily consume take advantages of the logistics services; economic globalisation, enhanced by the dramatic reduction of unitary transportation costs, has increased the relevance of logistics and its impact on the competitiveness of countries (e.g. Clark et al., 2004). Despite this importance, as argued by several authors, starting from Chow et al. (1994), a definition of logistics performance – and its related measure – is not easy to be universally identified due to the heterogeneity of activities included in the logistics sector.

As argued by Beniamino Pagliaro (2013) on a paper studying Italian logistics: "without the net […assured by logistics activities] our Country has grown till it was possible" but without an expansion of this "net" economic growth is harder to realize. The recent economic crisis showed some weaknesses that already existed but were previously hidden by the GDP and industrial growth and today the lack of efficiency in the logistics sector is becoming more evident than in the past (Confetra, 2011). Given the current role for logistics, the value added depend above all on the ability to provide solutions that implement the efficiency across the overall supply chain. This aspect depends mainly on the range and the efficiency of higher value added services offered by logistics providers to the industrial sector. As stressed in Ferrari et al. (2013) and recalled by Ferrari et al. (2014), Italian logistics firms register a softly decreasing trend for efficiency also due to their small size (on average) that prevents the exploitation of scale economies. Moreover, Ferrari et al. (2013) finally show that some variables like the legal form of companies and their size may become strategic elements for efficiency gains.

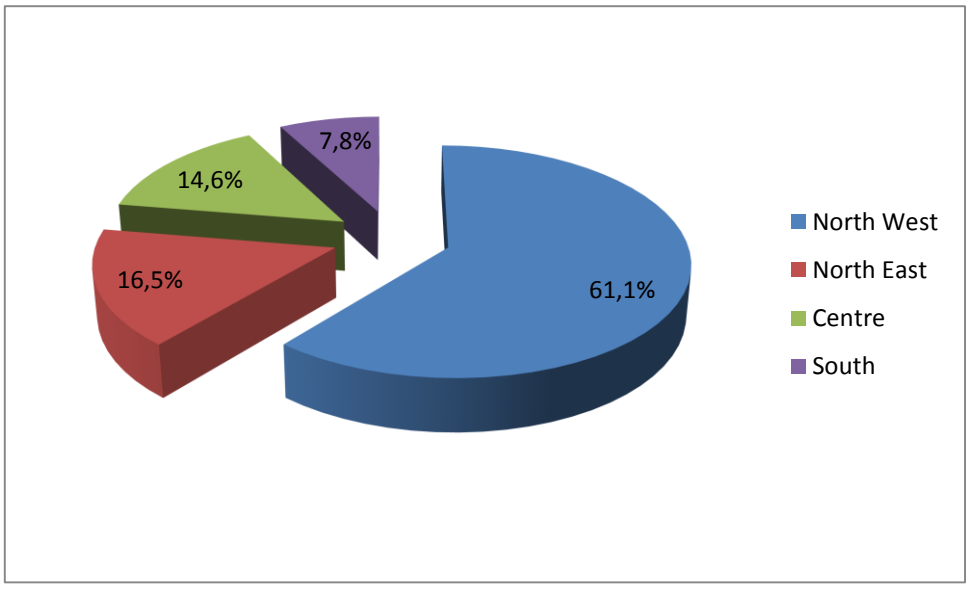
The present paper tests these findings using a two-stage methodology in order to verify the role that some firms' characteristics may play in conditioning or increasing the sample efficiency and enlarging the period of analysis as well. The sample consists of 139 logistics firms headquartered in Italy whose primary activity is recorded with the NACE code n.522922 and financial data have been extracted by the Cebil-Cerved database provided the Italian Chambers of Commerce. Fig. 1 exhibits the distribution of the sampled firms on the Italian macro-regions. The majority is located in the North of the Country (equally distributed in the North West and North East regions), while only a fifth of the sample is localised in the Southern part of Italy and the lower quote is located in the Centre. The distribution of revenues collected by our sample confirms a relevant concentration in the North West (see fig. 2, referred to 2012), that accounts for over 60% of global revenues; North East (16%), Centre (14.6%) and South (7.8%) follow.

Figure 1: Sample distribution



Source: Our elaboration on Cebil-Cerved data.

Figure 2: Sample distribution in terms of revenues for the year 2012



Source: Our elaboration on Cebil-Cerved data.

The impact of the economic crisis on the logistics sector is testified by the fact the in all macro-regions, but North West, the number of firms recording a volume of revenues higher than the regional mean has been decreasing since 2006.

2. Literature Review

In the recent years, several papers (e.g. Wanke, 2012; Dayou, 2010; Liu e Fu, 2009; Zhou et al., 2008; Min and Joo, 2006 and 2009) have focused their attention on the efficiency in the logistics industry, exploiting no parametric techniques, such as Data Envelopment Analysis (DEA), in order to estimate the optimal

quantities of inputs and outputs of efficient units, taking into account the potential heterogeneity of the typical productive factor mix for logistics.

Wanke (2012) carries out an efficiency analysis on Brazilian logistics firms aiming at identifying the main determinants, while the other cited authors focus on Chinese firms, both in general terms – Min e Joo (2006 e 2009) and Zhou et al. (2008) –, trying to define specific impact factors: for example, Dayou (2010) analyses listed companies aiming to define a link between efficiency and quotation trend, while Liu and Fu (2009) study the possible links between efficiency and the used technology.

Finally, Ferrari et al. (2013) used DEA to get the efficiency trend both for a closed and for an open sample of Italian logistics firms and found that some firms' characteristics (like type of corporation, size and geographical localization) typically match with higher efficiency levels. Thus, previous studies on the logistics efficiency have been generally directed to rank different providers or to link efficiency levels to some specific variables more than discovering aspects that may influence the achievement of a specific efficiency level. To the best of our knowledge no other kind of papers investigate these items in this strand of literature.

How to analyse the role and the impact of the so called environmental variables on efficiency represents a well debated open question (e.g. Barnum and Gleason, 2008; Bracalente and Polinori, 2010). Some authors apply a two-stage procedure: the efficiency scores – worked out at the first stage with traditional techniques – are regressed on possible environmental or firms' specific variables at the second stage. To this end, while some papers exploit traditional econometric models (e.g. Buzzo Margari et al., 2007; Balaguer-Coll et al., 2007), others shed light on possible distortions linked to the potential correlations among these explicative variables and the efficiency levels[2].

To overcome these shortcomings, starting from the seminal paper written by Simar and Wilson (2007), potential distortions are corrected by using at the second stage some bootstrapping procedures. Recently Bergantino et al. (2013) and da De Oliveira and Cariou (2014) adopted this approach in the transport field: while the former studies the role for transportation infrastructures on the efficiency of R&D at a regional level; the latter investigates the determinants of the efficiency of container ports. Following this strand of literature, the present paper exploit this technique in order to better understand the role of some explicative firms' specific variables in determining the efficiency of logistics sector for a seven years period.

3. Methodology

Our analysis adopts a two-stage procedure: at the first stage efficiency scores are found through the Data Envelopment Analysis (DEA) with variable returns to scale (VRS)[3] (we carried out also the analysis with the constant returns to scale [CRS]; the results – not reported in the paper but available upon request – are consistent to the those shown in this paper); and at the second stage a truncated regression is used with bootstrapping (2,000 bootstrap replications) for the selected firms, in order to estimate the links among the efficiency scores and some firms' specific variables.

[2] For example Kumbhakar and Lovell (2000) highlight some econometric problems if the estimated efficiencies (via SFA) are regressed against other exogenous variables in a second-stage regression.

[3] The variable returns to scale are preferred for the selected sample, taking into account the existing size differences for the analysed logistics firms.

Both stages use data covering the period 2006-2012: DEA at the first stage exploits some balance sheet data (i.e. revenues, labour costs, material costs, services costs and tangible fixed assets); the second stage regression exploits some firms' specific attributes (e.g. internationalization, specialization, age, type of corporation and size). The selected firms constitute a cohort (or a closed sample of firms) characterised by the availability of data for the overall considered period, as this time windows analysis drives to a homogenous trend of comparable outcomes.

3.1. The data

The model use information about economic and financial variables and about environmental firms' variables. As recalled, economic and financial data refer to the tangible fixed assets and to the main costs data: labour, material and services costs. Table 1 shows the descriptive statistics concerning the balance sheet data for the year 2012, while in appendix same statistics are provided for each year and for the average values of the overall period (2006-2012). The North West of Italy exhibits a mean level for revenues well above the other Italian regions. Moreover, North Western average levels for other variables, with the exception of tangible fixed assets, always overcome the values registered by the other Italian regions.

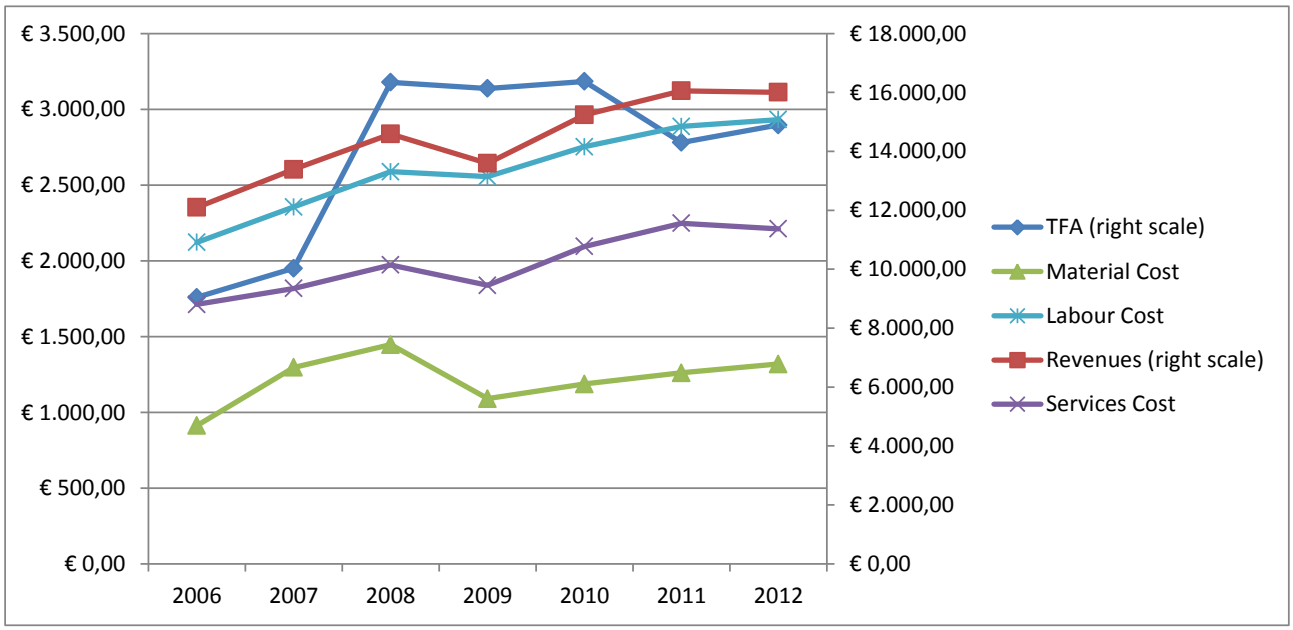
Table 1: descriptive statistics for the year 2012.

	Revenues				Tangible fixed assets		
	MEAN	MAX	MIN		MEAN	MAX	MIN
NW	30,192.16	53,864.00	218.00	NW	2,482.73	31,961.00	1.00
NE	8,716.10	67,500.00	139.00	NE	2,921.33	36,635.00	2.00
CE	12,951.12	112,815.00	585.00	CE	3,380.92	23,988.00	5.00
S	6,686.81	75,569.00	153.00	S	3,213.96	34,790.00	2.00
	Material costs				Labour costs		
	MEAN	MAX	MIN		MEAN	MAX	MIN
NW	2,489.51	56,993.00	1.00	NW	4,302.07	6,561.00	8.00
NE	740.45	4,887.00	4.00	NE	2,402.98	22,521.00	54.00
CE	522.24	7,537.00	1.00	CE	3,204.48	56,629.00	65.00
S	1,027.65	17,392.00	1.00	S	1,247.92	13,619.00	50.00
	Services costs						
	MEAN	MAX	MIN				
NW	22,751.71	53,160.00	96.00				
NE	5,383.90	49,731.00	11.00				
CE	8,807.40	75,075.00	36.00				
S	4,199.81	43,085.00	48.00				

Source: Our elaboration on Cebil-Cerved data. Data in thousands of euro.

Data in table 1 represent inputs and output for the first stage analysis. In figure 3 average trends for these variables are shown, considering the overall values per single financial source.

Figure 3: Average trend for the first stage data



Source: Our elaboration on Cebil-Cerved data.

The considered variables show only a soft increase during the period, mainly due to the ongoing economic crisis that is characterising Italian economy since 2008 (in 2008-2009 the crisis effects are well visible in fig. 3).

Table 2 reports the firms' specific variables used at the second stage. These variables – representing company characteristics that may potentially impact on efficiency scores and that in accordance with the definition of logistics, may represent an added value for the providers' clients – are: internationalization (dummy that is 1 if the selected firm controls foreign firms or dispose of stable foreign organizations or simply offers export services as detectable from the website), specialization (dummy that is 1 if the selected firm offers logistics services in favour of a specific industrial chain, while it is 0 if it offers diversified logistics services), age (continuous variable given by the difference between the foundation year and the reference year for each balance sheet data), size (dummy which is 1 when the selected firm size is over the sample median) and type of corporation (dummy that is 1 in case of limited corporations and 0 in case of cooperatives or consortia). Finally we use a territorial variable, given by the Italian region where the company's headquarters is located.

Table 2: descriptive statistics for the second stage variables.

	Mean	Median	1st quartile	3rd quartile
Internationalization	0.22	0	0	0
Specialization	0.33	0	0	1
Age	17.18	12	9	19
Size	0.50	1	0	1

Type of corporation	0.83	1	1	1

Statistics referred to dummy variables (with the exception of Age) for 973 observations.

We use at the most binary variables, e.g. if a selected firm is internationalized, the related dummy takes value 1 (else 0). The low propensity to internationalization for Italian logistics firms is testified by the null value for the median and by a 0.2 value for the mean. Then, only a minor share of our sample is specialized in favour of a specific productive chain. Considering the *age* variable, the set of companies studied is in a maturity stage (mean age: 17 years; median age: 12 years). As for the type of corporations, limited companies largely prevail in the sample.

3.2. First stage

Logistics firms offer a wide range of heterogeneous services, such as transportation, goods distribution, packaging, value added services, etc. Given this heterogeneity, it should be preferable exploiting a non-parametric method in order to avoid distortions due to a pre-determined production function, as discussed by Ferrari et al. (2013). DEA is one of the most widespread non-parametric methods to analyse both logistics and transportation sectors: this linear optimization technique compares different firms' performances (Decision Making Units – DMU) through their input and output profile (see Wanke, 2012; Basta and Ferrari, 2010; Min and Joo, 2006). It aims at selecting the firms that, given a certain input mix, maximize their output (or, vice versa, given a certain output, are able to minimize their input mix), we may use an *input oriented* DEA (output maximization) or an *output oriented* DEA (input minimization). After identifying the efficient firms' set, it is possible to define the efficiency frontier, while efficiency scores are given taking into account the distance of each firm from this frontier: these scores reflect efficiency in relative terms and the distance allows to carry out a correct comparison only within the selected sample or among homogeneous groups of DMUs (as possible in our case with the selected *time windows*).

From a formal point of view, given K=1,2,…,k selected firms and $X^k = x_1^k, x_2^k, \dots, x_m^k$ an input set with $Y^k = y_1^k, y_2^k, \dots, y_n^k$ the related output set and $\boldsymbol{\lambda}$ a non-negative matrix with all the elements λ_j, non-negative and fit to estimate θ through the following system:

$$min\ \theta$$

$$subject\ to$$

$$\theta xk - X\boldsymbol{\lambda} \geq 0$$

$$Y\boldsymbol{\lambda} \geq yk$$

$$\sum_{j=1}^{k} \lambda_j = 1$$

$$\lambda_j \geq 0$$

Solving this linear optimization model each firm obtain an efficiency score. This model was founded on Koopmans (1951) and Farrel (1957) assumptions and its formulation reflects the developments by Banker et al. (1984) to study the efficiency levels under the hypothesis of variable returns to scale.

The analysis has been conducted using one output and four inputs: on the one hand it exploits firms' revenues and on the other hand labour, services and material costs and tangible fixed assets are considered.

Taking into account the possible distortions due to some outliers, the analysis has been carried out both with all the selected DMUs, and without those reporting excessively high or low values for inputs and output (outliers). In both cases, beyond some specific scores differences, the efficiency trend and average level looks very similar, giving robustness to our findings.

3.3. Second stage

In the second step of the analysis, the efficiency scores for each firm are used as dependent variable in a second stage regression based on the method proposed by Simar and Wilson (2007) fluctuating from simple OLS regressions to more sophisticated methods avoiding distorted outcomes. Recently several authors used multi-step approaches in order to better understand efficiency level and performance in different transport industries, such as maritime (e.g. Bang et al., 2012), ports (Bergantino and Musso, 2010), airports (e.g. Gillen and Lall, 1997) and other related industries.

Following De Oliveira and Cariou (2014), we exploit a truncated bootstrapped regression that iterates the estimates, in order to identify the statistics distribution where unknown, due to the sampling design[4] (Green, 2008).

The regression is:

$$DEA_k = \beta z_k + \varepsilon_k$$

where DEA represents the efficiency score for the k^{th} DMU, and z stays for the set of firms' specific variables, potentially impacting on efficiency, while ε represents the error term.

The second stage estimation aims at determining the possible links among efficiency scores and firms' conditioning variables (z). Keeping in mind the available micro-data and the literature about the main firms' features impacting on DMUs' productivity, the following variables were selected: size, specialization, internationalization, age, geographical localization (the four Italian macro-regions) and type of corporation. These covariates are not exhaustive, since other possible explicative variables may exert some influence on firms' efficiency (e.g. for the variable "internationalization" it should be preferable to use continuous variables such as export revenues, but data are not available[5]).

[4] We provide a cluster analysis. The Simar and Wilson (2007) bootstrapped regression remove the potential estimates distortion for the two-stage approach, that is debated in literature. This distortion may come from the eventual high correlation among the second stage explicative variables, the efficiency scores and the inputs and outputs used for the DEA (however we observed a very low correlations among our variables, through the correlogram).

[5] In theory these data are available in the Bureau Van Dijk database, but since almost all firms report missing values, we are not able to exploit them.

At the second stage, another variable often used is the per capita GDP: we introduced also these information at the NUTS-3 level in our dataset[6], but the analysis of the related results shows that this variable is never statistically significant, determining small variations on the remaining covariates (hence, it was removed from the analysis that follows). Finally, in the same way we introduced a NUTS-3 level index for infrastructure endowment (i.e. Tagliacarne database for the examined period) but also in this case, considered the low variability between and within the values, the related coefficient proved not statistically significant, without any relevant effect on other covariates.

4. Results and discussion

According to the outcomes of the first stage analysis, the mean efficiency for our sample exhibits a decreasing trend during the period 2006-2012[7], even with a rebound starting from 2010. Looking at table 3, the VRS-DEA analysis reports a progressive growth for the number of efficient DMUs till 2010 and a decreasing trend in the following two years.

Table 3: DEA-VRS results

	2006	2007	2008	2009	2010	2011	2012
Efficient DMU	45	49	48	50	57	53	49
Min	0.494	0.437	0.501	0.410	0.485	0.339	0.521
MAX	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Variance	0.008	0.010	0.006	0.021	0.008	0.013	0.011
Mean	0.925	0.921	0.942	0.877	0.929	0.912	0.920

An efficiency gap may depend on technical features or in a not-optimal size with respect to the market features. That is why efficiency scores are split into pure efficiency and scale efficiency scores. The VRS-DEA scores represent the pure efficiency, while the scale efficiency scores are produced by the ratio between the CRS-DEA and the VRS-DEA scores. Scale efficiency results are shown in table 4.

We find that scale efficiency exhibits the same trend as the pure efficiency (see table 3), even if a higher number of DMUs do not reach an optimal scale; we conclude that scale efficiency is one of the main causes for Italian logistics firms' inefficiency. Moreover, also Ferrari et al. (2013) by carrying out a specific return to scale analysis, demonstrated a need for a different size for Italian logistics firms, in order to exploit potential economies of scale.

[6] In EU statistics, NUTS-3 regions correspond to the smallest administrative regions in which statistical data can be collected (i.e. in Italy they represents the provinces).

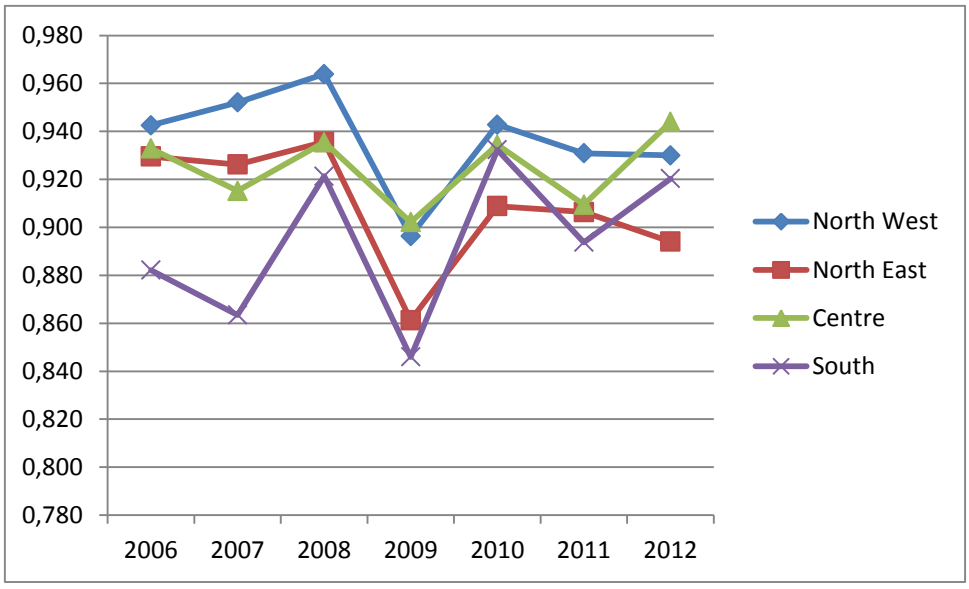
[7] By using a "closed sample" we are able to check for the efficiency evolution during the examined years; however, the mean efficiency level probably overestimates the real Italian logistics efficiency level (as also underlined by Ferrari et al., 2013).

Table 4: Scale efficiency summary

	2006	2007	2008	2009	2010	2011	2012
Scale efficiency (mean)	*0.963*	*0.968*	*0.969*	*0.895*	*0.956*	*0.954*	*0.954*
% of efficient DMUs	*80*	*79*	*78*	*86*	*80*	*78*	*79*

The efficiency trends for the four Italian macro-region, appear to be rather coherent with the national trend apart some (small) differences. For the North East, for example, despite the fluctuations, efficiency shows a slight reduction over the period and at the end of the 2012, this is the region with the lowest efficiency scores. The North West too registers a small decrease. On the contrary, even if struck by the economic crisis, the Centre and the South of Italy exhibit a small increase for efficiency level. But if we look at the mean efficiency score for the overall period, instead of the seven years trend, we find that the North West is the best performing area (mean efficiency: 0.937), while the South shows the worst results (0.894); the Centre (0.925) and the North East (0.909) stay in intermediate positions.

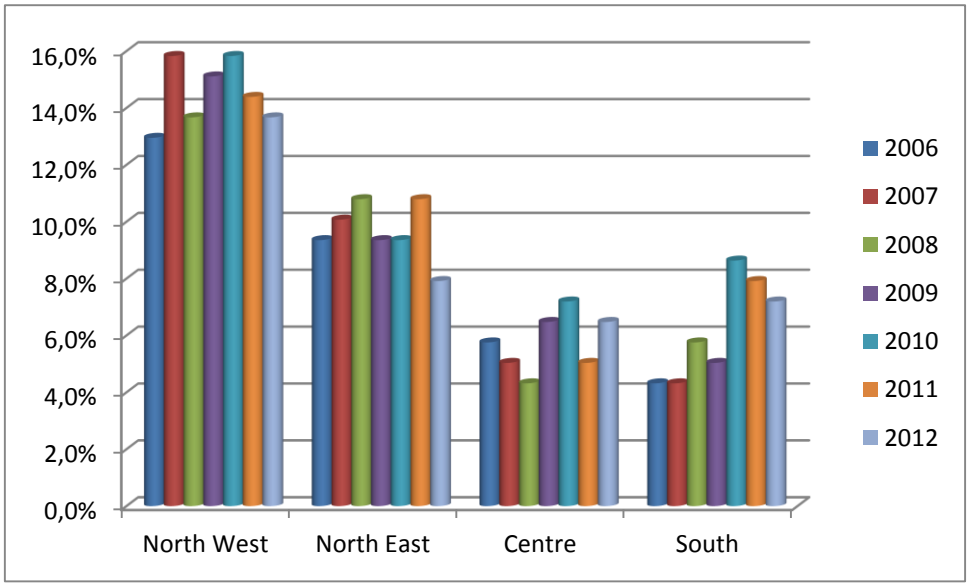
Figure 4: efficiency trend by geographical areas



Source: Our elaboration on Cebil-Cerved data.

Moreover, the large majority of efficient DMUs stays in the North West. Starting from the second half of the considered period we observe a reduction in the number of efficient DMUs, especially in the Northern regions, while an increase is registered for the South located firms.

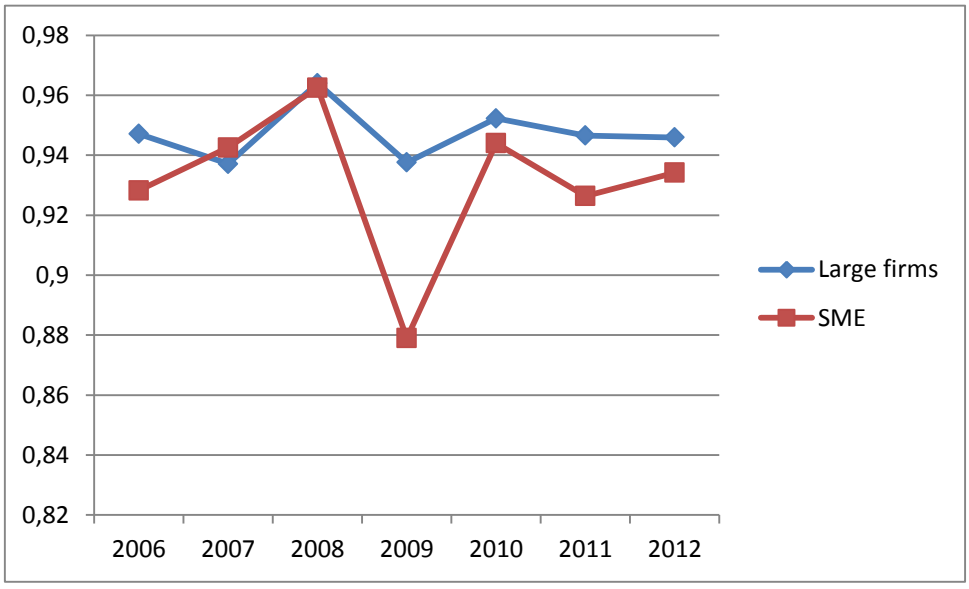
Figure 5: density of efficient DMUs by geographical areas



Source: Our elaboration on Cebil-Cerved data.

To identify the possible impact of firms' size on efficiency, we divided our sample between the large firms (or those with revenues above median of the sample) and small and medium enterprises (SMEs; having revenues under the sample median). Two distinct DEA analysis were carried out on these subsamples whose results are summarized in figure 6. The large firms always perform better than the SMEs; moreover, large firms show more stable results over the seven years and proved resilient also at the crisis climax.

Figure 6: efficiency scores by firms' size



Source: Our elaboration on Cebil-Cerved data.

Table 5 summarizes the results coming from the second stage regression.

Table 5: regression results

VARIABLES	ITALY	NORTH WEST	NORTH EAST	CENTRE	SOUTH
D_int	0.0323 (0.0544)	0.0574* (0.0323)	-0.0489 (0.1171)	0.0569 (0.0371)	Om.
D_spec	-0.0640* (0.0367)	0.0007 (0.0633)	-0.0646 (0.0671)	-0.0292 (0.0275)	-0.0759 (0.2510)
Age	-0.00379*** (0.00127)	-0.00172 (0.0013)	-0.0034 (0.0030)	-0.0013 (0.0012)	-0.0036 (0.0172)
D_dim	0.171*** (0.0467)	0.1274*** (0.0441)	0.2078*** (0.0774)	0.0769** (0.3042)	0.1439 (0.2378)
D_fg	-0.0617 (0.0595)	-0.0207 (0.0864)	-0.1008 (0.0834)	0.0223 (0.0389)	-0.2802 (1.3455)
Areas Dummy	yes	no	no	no	no
Years Dummy	yes	yes	yes	yes	yes
Constant	*1.155**** *(0.0882)*	*0.964**** *(0.0859)*	*1.155**** *(0.123)*	*0.893**** *(0.0437)*	*1,485* *(1.421)*
Observations	*622*	*174*	*207*	*119*	*122*
Wald chi2(14)	*43.91*	*27.46*	*25.76*	*41.05*	*6.05*

Robust standard errors in parenthesis*** p<0.01, ** p<0.05, * p<0.1.
Truncated Regression. Bootstrap replications (2000) based on 121 clusters.

The outcomes are coherent with the findings showed by Ferrari et al. (2013)[8]. Looking at table 5, first we find that *size* has a positive and statistically significant effect, so that, on average, forms with revenues over the sample median show higher efficiency scores[9]. Other two explicative variables show statistically significant coefficients, the first at a 1 per cent and the second at a 5 per cent confidence interval. On the one hand the variable *age* has a negative but very low coefficient; indeed, on average long-lived firms exhibit lower efficiency during the crisis, presumably reacting slowly to a changed market scenario. On the other hand, the variable *specialization* registers a negative effect on efficiency: being specialized to support a specific productive chain should represents a weakness point during unfavourable stages of the economic cycle, while a diversified services supply should contribute to increase the efficiency score.

On the contrary, the variables *type of corporation* and *internationalization* register non-significant impact on efficiency. Considering the first covariate, Ferrari et al. (2013) identified on a descriptive point of view a better performance for cooperative firms; starting by that observation, we replaced our dummy variable, distinguishing between limited corporations and other forms of corporations, with a variable assuming different values for each specific different Italian type of corporation (limited companies, guarantees

[8] Ferrari et al. (2013) – analysing the period 2006-2010 – shed light on what follows: logistics firms' efficiency exhibited a small decrease, due to the demand fall linked to the crisis; at the South efficiency was lower; cooperative firms performed better, having lower tangible fixed assets and more flexible labour force; finally, large firms demonstrated more efficient and were more resilient to the adverse economic conjuncture.

[9] No relevant correlations were discovered among firms' specific variables, efficiency levels and the inputs and the output used at the first stage.

companies, cooperative companies and consortia). The related regression[10] confirms that cooperative companies are the most efficient, but coefficients are just under the 10 per cent threshold for the statistics robustness.

In relation to the variable *internationalization*, few firms out of our sample (20%) are internationalized (dummy: 1); these firms are mostly concentrated in the North West of Italy. Moreover, we replaced the covariate *internationalization* with a variable called Multinational (proxing firms belonging to a multinational group), in order to control for a possible impact on efficiency, but again our coefficient proved not statistically significant.

Our second stage regression results show that firms localized in the South are less efficient, while the Years dummies reflect the economic cycle evolution (the demand collapse largely impacted on the efficiency fall for the year 2009).

The outcomes shown in table 5 are confirmed also by the Constant Return to Scale DEA efficiency scores (instead of the VRS scores)[11] as dependent variable in the second stage regression. Moreover, to check the robustness of results, the analysis was repeated excluding possible sample's outliers[12]. Again, we find that *size* impacts on efficiency, while *age* has a negative effect on the firms' ability to react to a negative conjuncture, even if very low[13].

Finally, the analysis was repeated for each Italian macro-region to check for the impact of the explicative variables across geographic localization. The outcomes depend also by the heterogeneous distribution of sample across the Italian territory; all in all we find again that *size* is the most impacting variable (except for the South), while *age* and *specialization* lose statistics significance; in the North West, where is located the large majority of internationalized firms, also the dummy *internationalization* acquires a positive effect on efficiency.

5. Concluding remarks

Logistics is becoming a major fundamental economic sector not only as an industry itself but mainly for its contribution to featuring manufacturing firms' productivity. This is the reason why we investigated the Italian logistics industry through an analysis based on a two-stage methodology aiming at (a) estimating the Italian logistics firms efficiency and (b) defining – and possibly measuring – some characteristics impacting on the efficiency level.

On a first stage the analysis focuses on Italian logistics providers by exploiting the Data Envelopment Analysis based on 2006-2013 financial data. According to our main findings, Italian logistics providers do not suffer by relevant efficiency gaps, but during this period of economic crisis efficiency weakened, due to the diminishing demand for services (especially in the year 2009). Moreover, following the recent literature and using a new methodology to investigate the firms' efficiency, we checked for the role of some firms' specific factors on their performance.

[10] The results are available upon request by the authors.
[11] Size and Specialization have a less significant coefficient.
[12] We carried out two different outlier analysis: first we focused only on revenues and dropped firms at the last percentile; second we dropped firms at the last percentile for all inputs and for the output.
[13] In this case the coefficient for the variable Specialization registers a statistics robustness loss.

The second stage analysis – even if not exhaustive (due to the available data that do not cover all the possible variables impacting on firms' efficiency) – shows that firms installed in the South underperformed in terms of efficiency scores in comparison with others Italian macro-regions[14]. Second, small and medium enterprises performed worse than the other and they suffered more than big companies from the economic crisis. Regarding the variable *age* – or being an older firm – impacted negatively (at a lessened pace) on efficiency (long-lived firms with more stable reference market react less rapidly to a diminishing demand). Being specialized to offer logistics service in favor of a specific industrial chain resulted as a weakness point for efficiency (the adverse cycle may determine a fall in the demand for specific industrial chains, not compensated by an adequate diversification for supply). Moreover, in the North West, the region that host about 60% of internationalized firms, the variable *internationalization* has a positive impact on efficiency. Finally, three other possible covariates – be part of a multinational group; the NUTS-3 level per capita GDP; and the NUTS-3 level infrastructure endowment – do not robustly conditioned the efficiency level (for the two latter variables, due also to the low variability for available data). Our analysis not only shows the regional gap of logistics providers, for instance in terms of size, but underlines main characteristics that impact on the logistics efficiency level: size, flexibility and possibility to be part of an international network. Where these factors are more common, logistics providers perform better and are more resilient to the economic crisis.

Being aware of the limitations of the study, it should be useful to further investigate the optimal size for logistics firms and other aspects, such as the capability to promptly react to a change in market conditions, the ability to diversify business in favor of other destination markets or industrial chains and the propensity to offer services at an international scale.

[14] Years dummy registers a statistically significant and negative coefficient for the years 2009 and 2011, when the crisis was more severe.

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Appendix

Table 1a: sample descriptive statistics, years 2006-2011

2006							2007						
	Revenues			Tangible Fixed Assets				Revenues			Tangible Fixed Assets		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	23,284	33,731	273	1,800	24,797	1	*NW*	25,849	37,361	261	2.089	29.484	1
NE	7,122	42,578	168	1,787	25,160	4	*NE*	7,822	47,095	179	1.741	25.646	3
CE	8,920	66,786	122	1,396	11,425	5	*CE*	9,908	76,961	190	1.806	22.031	7
S	4,241	51,814	42	2,056	20,446	4	*S*	4,579	55,835	110	2.262	22.028	5
	Material Costs			Labour Costs				Material Costs			Labour Costs		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	2,137	34,033	1	3,425	8,503	12	*NW*	3,250	50,982	2	3.749	8.445	5
NE	368	3,146	2	1,782	19,838	27	*NE*	417	3,673	3	2.026	22.503	28
CE	341	4,694	6	2,013	30,540	29	*CE*	352	4,545	2	2.201	35.354	38
S	244	2,748	1	590	4,701	2	*S*	272	2,066	1	700	6.063	15
	Services Costs							Services Costs					
	MEAN	MAX	MIN					MEAN	MAX	MIN			
NW	17,380	27,690	82				*NW*	17,918	30,976	133			
NE	4,680	31,909	13				*NE*	5,163	35,682	10			
CE	6,270	28,711	6				*CE*	7,107	35,485	9			
S	3,371	44,762	5				*S*	3,721	47,812	11			

2008							2009						
	Revenues			Tangible Fixed Assets				Revenues			Tangible Fixed Assets		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	27,747	39,635	239	2,596	29,568	1	*NW*	25,453	39.603	229	2.526	30.596	1
NE	8,087	48,329	187	2,802	29,314	8	*NE*	7,190	49.164	141	2.831	32.615	8
CE	11,274	88,449	483	2,597	32,258	6	*CE*	12,205	93.399	628	2.313	31.462	5
S	5,995	72,080	203	5,473	61,446	9	*S*	5,206	47.359	258	5.598	62.013	9
	Material Costs			Labour Costs				Material Costs			Labour Costs		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	3,482	75,909	1	4,159	8,679	14	*NW*	2,440	45.946	1	3.926	8.140	17
NE	508	3,744	3	2,212	23,441	31	*NE*	512	4.437	3	2.206	21.797	29
CE	496	5,228	3	2,346	37,236	58	*CE*	373	4.160	1	2.511	40.399	46
S	392	3,157	2	793	6,031	45	*S*	408	3.633	1	876	5.571	48
	Services Costs							Services Costs					
	MEAN	MAX	MIN					MEAN	MAX	MIN			
NW	19,281	37,996	101				*NW*	18,070	37,191	92			
NE	5,156	36,683	11				*NE*	4,292	37,060	12			
CE	8,243	43,070	15				*CE*	9,017	66,000	13			
S	4,555	61,807	16				*S*	3,606	37,467	32			

2010							2011						
	Revenues			Tangible Fixed Assets				Revenues			Tangible Fixed Assets		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	29,759	51,782	247	2,495	29,438	2	*NW*	30,856	57,901	255	2,588	30,667	1
NE	7,552	52,882	140	2,927	33,443	6	*NE*	8,398	62,511	139	2,896	34,145	1
CE	12,712	102,025	452	2,430	30,198	7	*CE*	13,172	110,930	541	2,346	25,265	6
S	5,452	48,113	223	5,638	63,416	4	*S*	6,105	62,304	118	3,449	35,254	4
	Material Costs			Labour Costs				Material Costs			Labour Costs		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	2,521	56,771	1	4,423	8,016	1	*NW*	2,528	58,166	1	4,454	7,647	11
NE	612	4,808	2	2,198	17,553	32	*NE*	764	5,342	3	2,346	20,274	42
CE	468	5,069	1	2,782	47,562	92	*CE*	535	5,998	4	3,071	53,156	107
S	530	3,957	1	819	4.208	47	*S*	594	6,018	1	960	7,639	50
	Services Costs							Services Costs					
	MEAN	MAX	MIN					MEAN	MAX	MIN			
NW	21,811	50,697	120				*NW*	23,223	57,094	105			
NE	4,526	39,590	11				*NE*	5,130	46,318	9			
CE	9,249	80,810	17				*CE*	9,402	81,068	22			
S	3,589	35,227	40				*S*	4,224	45,863	38			

2012							Mean 2006-2012						
	Revenues			Tangible Fixed Assets				Revenues			Tangible Fixed Assets		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	30,192	53,864	218	2,483	31.961	1	*NW*	27,591	57,901	218	2,368	31,961	1
NE	8,716	67,500	139	2,921	36,635	2	*NE*	7,841	67,500	139	2,558	36,635	1
CE	12,951	112,815	585	3,381	23,988	5	*CE*	11,592	112,815	122	2,324	32,258	5
S	6,687	75,569	153	3,214	34,790	2	*S*	5,466	75,569	42	3,956	63,416	2
	Material Costs			Labour Costs				Material Costs			Labour Costs		
	MEAN	MAX	MIN	MEAN	MAX	MIN		MEAN	MAX	MIN	MEAN	MAX	MIN
NW	2,490	56,993	1	4,302	6,561	8	*NW*	2,693	75,909	1	4,062	8,679	1
NE	740	4,887	4	2,403	22,521	54	*NE*	560	5,342	2	2,167	23,441	27
CE	522	7,537	1	3,204	56,629	65	*CE*	441	7,537	1	2,590	56,629	29
S	1,028	17,392	1	1,248	13,619	50	*S*	495	17,392	1	855	13,619	2
	Services Costs							Services Costs					
	MEAN	MAX	MIN					MEAN	MAX	MIN			
NW	22,752	53,160	96				*NW*	20,062	57,094	82			
NE	5,384	49,731	11				*NE*	4,904	49,731	9			
CE	8,807	75,075	36				*CE*	8,299	81,068	6			
S	4,200	43,085	48				*S*	3,895	61,807	5			

Source: Own elaboration on Cebil-Cerved data. Data are expressed in thousand euro.