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Ph.D. Dissertation

Efficiency and Ratio Analysis in Assessing Firms' Corporate Performance. A Closer Look to the Case of Romania.

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To My Parents

“No matter how refined and how elaborate the analysis, if it rests solely on the short view it will still be…a structure built on shifting sands.”

Jacob Viner [1958, pp.112-13]

Table of Contents

List of Tables and Figures iii

Acknowledgements v

Introduction vii

Chapter 1. The Construction of a European Industrial Database 1
1.1. General Information 1
1.2. Detection and Treatment of the Influential and Extreme Observations 5
Bibliography 12
Appendix 1. 12
Producer Price Indices 14
Descriptive Statistics on the Data per Sector 15

Chapter 2. Output Growth and Explanatory Factors: Productivity and Growth in Inputs 27
2.1. Introduction 27
2.2. Determining the Efficient Frontier 31
2.3. Best Practice Frontier in a Non-Parametric Framework and the Distance Function 32
2.3.1. The Distance Function 35
2.3.2. Components of Productivity Change: Technical Change, Technical Efficiency Change and Increments in Input Usage 39
2.3.3. The Quantification of Distance Functions 49
2.4. Variables Definition and Empirical Results 51
2.5. Concluding Remarks 60
Bibliography 62
Appendix 2.1. 68
A. Descriptive Statistics of the Efficiency Scores. Constant Returns to Scale Setting 68
B. Descriptive Statistics of the Efficiency Scores. Variable Returns to Scale Setting 74
Appendix 2.2. Scale Effects 80

Chapter 3. On the Measurement of Capacity Utilisation and Cost Efficiency: A Non-Parametric Approach at Firm Level 83
3.1. Introduction 83
3.2. Brief Review of the Literature on Capacity Utilisation 85
3.3. Modelling Cost Efficiency in the Short- and Long-Run 86
3.4. The Measurement of Frontier Efficiency in the Short- and Long-Run, and the Determination of Structural Efficiency 89
3.5. Data and Empirical Findings 95
3.6. Concluding Remarks 100
Bibliography 103
Appendix 3.1. The Depreciation Cost of Capital 106
Appendix 3.2. The Degree of Utilisation of the Fixed Inputs in the Short-Run 108
Appendix 3.3. Growth Rates of Fixed Assets 114
Appendix 3.4. Average Cost Efficiency 116

Chapter 4. A Non-Parametric Directional Distance Function Approach to Constrained Profit Maximisation 119
4.1. Introduction 119
4.2. Soft and Hard Budget Constraints. Concepts and Evidence 122
4.2.1. Soft Budget Constraint (SBC) 122
4.2.2. From Soft to Hard Budget Constraint Regime 125
4.3. Profit Maximisation and Directional Distance Functions 128
4.3.1. Nerlove's Profit Efficiency Measure 128
4.3.2. Directional Distance Function 129
4.3.3. Nerlovian Profit Efficiency Measurement and Decomposition 134
4.4. The Non-Parametric Optimisation Programs 137
4.4.1. Profit Function Maximisation and Directional Distance Function Programs 137
4.4.2. Constrained Profit Function and Directional Distance Functions. The Non-Parametric Models 139
4.5. Empirical Results 142
4.5.1. NPE Estimates and Decomposition 143
4.5.2. "T- test" Paired Samples Results 145
4.5.3. Framework of the Econometric Estimation 146
4.6. Concluding Remarks 152
Bibliography 156
Appendix 4.1. Average Number of Employees 162
Appendix 4.2.
A. Panel Data: T-test Results per Sector and Country 164
B. Panel Data LME Model Results – All Industry Sectors 167
C. Panel Data LME Model Results – per Sector Analysis 169
Appendix 4.3. Nerlovian Profit Efficiency 181

General Conclusions 205
General Bibliography 225

List of Tables and Figures

List of Tables

Chapter 1

Table 1.	Countries and Codes	1
Table 2.	Industry Sectors	2
Table 3.	Description of the Accounting Variables and the Relationship among them	2
Table 4.	Public and Private Companies Legal Forms	4
Table 5.	Breakdown of Companies per Categories of Legal Forms	4
Table 6.	Initial Structure of the Database	10
Table 7.	Final Structure of the Database	11

Chapter 2

Table 1.	Sector 172-Output Growth Decomposition with Initial and Final Year Data	52
Table 2.	TFP vs. variation in Inputs' Usage. CRS	55
Table 3.	TFP vs. variation in Inputs' Usage. VRS	56
Table 4.	Annual Real Growth Rates of GDP	57
Table 5.	Consumer Prices	58
Table 6.	Scale Effect – Sector 172	50

Chapter 3

Table 1.	Variables Used in the Analysis	95
Table 2.	Sector 172 - δ Values	96
Table 3.	The Degree of Utilisation of the Fixed Inputs in the Short-Run (CU)	96
Table 4.	Sector 172 – Growth Rates of Fixed Assets (GRFA)	98
Table 5.	CU vs. GRFA Relationship and the Business Environment	98
Table 6.	Average Cost Efficiency Results – Sector 172	99

Chapter 4

Table 1.	Labour Average – Sector 252	128
Table 2.	Financial Variables	143
Table 3.	Sector 172 – Profit Efficiency	144
Table 4.	T – test Results for Sector 172	145
Table 5.	Panel Data LME Model	148
Table 6.	LME Model for Sector 172	151

List of Figures

Chapter 2

Figure 1.	The Measurement of Technical Change	28
Figure 2.a.	Technical Inefficiency with Variable Returns to Scale Technology	38
Figure 2.b.	Technical Inefficiency with Constant Returns to Scale Technology	38
Figure 3.	Decomposition of the Output Growth Rate Due to Technical Change with Final Year Data	45
Figure 4.	Decomposition of the Output Growth Rate Due to Technical Change with Initial Year Data	47
Figure 5.	Decomposition of the Output Growth Rate Due to Technical Change when Averaging Final and Initial Year Results	49
Figure 6.	Infeasible Units	54
Figure 7.	Scale Effect Decomposition	59

Chapter 3

Figure 1.a.	Short-Run Cost Efficiency – Average Cost Minimisation Approach	91
Figure 1.b.	Short-Run Cost Efficiency – Variable inputs Orientation Approach	91
Figure 2.a.	Long-Run Cost Efficiency – Average Cost Minimisation Approach	93
Figure 2.b.	Long-Run Cost Efficiency – Variable Inputs Orientation Approach	93

Chapter 4

Figure 1.	The Directional Technology Distance Function	131
Figure 2.	Profit Maximisation	133
Figure 3.	Profit – Technology Duality	134
Figure 4.	Profit Efficiency Measures in Terms of Directional Distance Function	136
Figure 5.	Credit – Constrained Profit Maximisation	140
Figure 6.	Profit Maximisation with Binding Credit Constraint	141

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Introduction

The conceptual framework of this dissertation is defined by the use of Data Envelopment Analysis (DEA) tools for assessing corporate performance of firms and industrial sectors from countries acting long ago under the laws of the market mechanism, and from transition economies. DEA relates to the economic notion of a production function and an efficiency frontier in a non–parametric setting.

The application of DEA goes from non–profit organisations (such as schools, hospitals, etc.) to for–profit firms in a variety of fields: commercial firms, banking and finance, pharmaceutical firms, computer industry, grocery industry, agricultural farms, etc. Despite the large consideration of the technique in the banking and finance sectors, it was much less applied in other services and industrial sectors, and even less in transition economies.

The analysis performed here focuses on the estimates of targets provided by DEA for measuring and explaining the main determinants of corporate performance. This includes an assessment of the effects of economies of scale, benchmarking of a firm's output and profit performance, and assessment of the capacity utilisation degree, only to mention some of the applications to be found in this dissertation. From a methodological point of view, as we go over the chapters, we switch from a less restrictive framework of analysis, i.e. technical frontiers, to gradually more restrictive settings that is, cost and profit frontiers.

Alternative tools like e.g. ratio analysis, are insufficient for assessing performance, because it is not found to be suitable for setting targets so that units can become more efficient, and there are limitations when considering the effects of economies of scale or with the identification of benchmarking policies. These are the main reasons why DEA and/or regression analysis are used instead of or to complement ratio analysis.

We base our empirical analysis on a panel data which consists of firms grouped in six industrial sectors from the manufacturing industry, the main branches being: textiles; pulp, paper and paperboard; chemicals, and rubber and plastic products. The international dimension of the panel is given by the fact that we work with seven European countries, five of them belonging to the advanced market economies – Belgium, France, Italy, Netherlands, and Spain – and two from transition economies, Bulgaria and Romania respectively.

The database consists of accounting information, end-year observations, and covers a time period of four years, from 1995 to 1998. Our initial intention was to include more countries both from Western and Central and Eastern Europe, as well as a larger period of time, but due basically to data availability and to the necessity of shaping a *balanced panel*, the final structure is the one briefly introduced here, and explained more in detail in Chapter 1 of the dissertation.

The main reason why we combine here advanced and transition economies in a sole data set it is justified by the fact that we would like to use the performance of the Western economies as a comparative benchmark for the two transition countries. Moreover, it is common knowledge that Bulgaria and Romania are considered to go at a slower path with respect to other countries in transition like e.g. Czech Republic, Hungary and Poland.

The transition process to the market economy started in almost all the countries in Eastern Europe in the early ‘90s, and implied fundamental changes in all the aspects and fields of economic and political activity. Many studies on transition have concentrated on productivity growth but very few – both at macro and micro level – applied techniques related to the conceptual framework of production functions, economies of scale, non-parametric frontier efficiency (DEA), cost efficiency, capacity utilisation degree or constrained profit maximisation.

The studies analysing convergence between the EU/OECD block and the Central and East European countries offer various perspectives of viewing the transition process: evolution of exchange rates, interest rates, inflation, unemployment, public debt or volatility of GDP are only some of the aspects more frequently treated. Our analysis is approaching the transition process from the perspective given by the benchmarking in efficiency between transition economies, and advanced market economies in the EU.

In **Chapter 2** of the dissertation we would like to give some more insight about the comparative performance of the countries in the data set in the field of productivity, measured by the growth rate of output (turnover), at firm level. Apart from one output we work also with three inputs: fixed assets, number of employees, and material expenses. The objective is to quantify the main contributing factors in explaining the growth in output, and hence firms' performance in productivity. The traditional literature on this topic gives as main explanatory factors for the observed changes in productivity: the technical efficiency change, technical change, and the increase in inputs' usage.

Technical efficiency change, so called *catching up* effect, is associated with the use of knowledge gained through imitation. The international diffusion of technology give the low-productivity countries the opportunity to adopt (imitate) the techniques of the leader and hence catch up with the higher productivity countries. Improvements in technical efficiency are assimilated in time with movements towards the production frontier. The second factor, technical change, measures the shifts in the production frontier and hence show the impact of innovation on productivity growth. The main sources of innovation are the R&D activities whose findings are later on incorporated into the productive activity, and the spill-over effects of R&D. Finally, the third factor, inputs usage, explains the growth in output determined by the disposability of new resources like raw materials, labour and capital, and can be viewed as a movement along the same production frontier.

The novelty about the non-parametric methodology (DEA) we use in Chapter 2 comes first, from the fact that it allows us to measure technical change, using three different settings: (a) work with final year data; (b) with initial year, and (c) averaging the results previously obtained in (a) and (b). Second, we capture the scale effect (usually isolated from the technical efficiency) from the decomposition of input usage factor.

At country level we would like this way to see which of the seven economies included in the data set is/are actually shifting the frontier, bearing the burden of investing in technology, which ones are just benefiting from imitation, and which of the countries are growing just because they are varying the level of inputs used in the production process. Great part of the empirical studies dedicated to explaining the differences between growth rates of countries follow the approach of the traditional neoclassical growth theory. They focus on the relationship between income distribution, capital accumulation and growth, but not on technology, usually assumed to have some public good characteristics. Studies such as Abramovitz[1] (1986), Baumol (1986), Maddison (1987), Baumol and Wolf (1988) or Barro and Sala-I-Martin (1992) are only some examples of the traditional view.

The opposite direction of investigation focus in the technology gap approach to the economic growth. The authors in this tradition argue that the differences in GDP per capita across countries are due to the technological differences. Moreover, many studies in this line distinguish between efficiency change (diffusion) and technical change (innovation). This decomposition is particularly important since most industrialized countries, it is argued, contribute to the technological frontier through innovation, although not to the same extent. The follower countries, on the contrary, often combine the diffusion of technology through adoption (imitation) and innovation. Fare et al. (1994) examined the changes in efficiency obtained from the decomposition of the Malmquist productivity change index in 17 OECD countries in the 1979-1988 period. They found that U.S. was the only country shifting the world technological frontier. Eaton and Kortum (1996), estimated a model to explain international patterns of productivity and patenting in 19 OECD countries in the 1986-1988 period. Their findings showed that more than 50% of the growth in each country in the sample derived from innovation in the U.S., Germany, and Japan. Taskin and Zaim (1997), study the productivity growth for a sample of 13 low-income and 10 high-income countries in the 1975-1990 period. Their findings show that technical change (innovation) is the main source of productivity growth for high-income countries.

[1] The complete references for the authors cited in Introduction can be found in the General Bibliography.

The analysis in Chapter 2 follows the second tradition. The empirical findings would allow us to bring some more evidence supporting the above mentioned hypothesis that the more developed economies are actually the ones who are shifting the production frontier while the transition countries are only catching up or just varying the input factor.

We perform the calculations in an output oriented setting, both with constant and variable returns to scale and hence can reach another objective which is to quantify the scale effects. Our data set covers a period of time of only four years which can be considered as being rather short. It is generally accepted that in the short–run firms are more likely to act upon the input factor while the effects of a technological improvement are expected to be stronger in the long–run. If this hypothesis turns out to be correct, we expect *a priori*, the input effect to be one significant explanatory component of the output growth rate. For this reason, the impact of inputs' usage in the level of output will be reinforced if the presence of increasing returns to scale prevails instead of decreasing returns to scale.

The first empirical results obtained in Chapter 2 put in evidence the fact that the main explanatory component of the output growth rate is on average the variation in inputs' usage followed by the catching up effect, and in the last place the technical change. In other words, firms are not particularly investing in new technology and in capital. Our hypothesis is that this situation is especially common to the firms in transition economies. These countries registered an output fall in the post communist period (after 1990s), and had moreover to adapt to the requirements imposed by the market economy system.

Blanchard (1997) speaks about two key elements of the transition process: reallocation and restructuring. According to the author, reallocation refers to the movement of production away from state to private ownership. Restructuring refers to changing the level and technical composition of labour and capital in search of cost and productive efficiency. Moreover, he distinguishes between initial restructuring and deep or strategic restructuring. Initial restructuring refers to labour adjustments required by the hardening of budget constraints. Deep or strategic restructuring requires substantial reforms to improve efficiency, such as an increase in the investment in new technology, replacement of obsolete capital, and vertical innovations in products.

Many empirical studies realised i.e., Djankov (1999), Repkine and Walsh (1999), Coricelli and Djankov (2001) or Earle and Telegdy (2002) confirm our hypothesis about Bulgaria and Romania, in particular: most of the restructuring measures contemplated mainly changes in the ownership structure of the firms, and labour shedding rather than improvements in operational performance of the firms.

In **Chapter 3**, we take up the issue of assessing firms' performance from the perspective of cost efficiency analysis, maintaining the non–parametric framework. The objective of the chapter is to present a method for estimating the inefficiency due to the existence of fixed input factors in the production process. The difficulty to adjust them in the short–run could generate variations in the degree of utilisation of the productive capacity.

The concept of capacity utilisation (CU) has been approached in the economic literature from various perspectives, but due to interpretation problems there does not exist an unanimous acceptance as to the most appropriate way of defining and measuring it. In Chapter 3, we treat the notion of CU from the perspective offered by the economic theory of the firm, as a short–run concept, depending on the level of the fixed inputs of the firm. Given that many times the concept of capacity is closely related to the technical characteristics of the productive process, DEA has the great advantage of adapting to the characteristics of the firms analysed without being necessary to specify any functional form in particular.

In general, the inefficiency in costs of the firms may be originated by more than one factor like i.e.: adjustment costs, administrative regulations, external factors or rationing measures. We are interested, in particular, in quantifying the cost inefficiency generated by the structural factors, in this case, the impossibility of the firms in the short–run to adjust the *fixed* (or quasi-fixed) inputs.

We construct a cost efficiency frontier with one output (turnover), and three inputs, material expenses, employee cost, and depreciation. With the methodology introduced in Chapter 3, input orientation and variable returns to scale, we calculate various elements like: (a) the degree of utilisation of the fixed inputs in the short–run. We define this coefficient as the ratio between the level of fixed inputs that minimise long–run total costs, and the observed level of fixed inputs; (b) cost efficiency coefficients in short–, and long–run, and finally, (c) structural efficiency defined as the ratio of long– and short–run cost efficiency coefficients.

We recall that our time period covers only four years, and for this reason the difference between short-, and long–run, does not refer actually to the length of the time horizon *per se* but rather to the fact that in the short–run the level of the fixed inputs cannot be varied at all (it is fixed). One aspect worthwhile mentioning about the methodology used in Chapter 3 is the way we incorporate this restriction: we impose a strict equality constraint on the level of the fixed assets in the short-run, and allow them to be varied only in the long–run. The way we incorporate this in the data is adjusting the long–run fixed assets with the depreciation rate.

The non–parametric framework allows us to construct a benchmark cost efficiency frontier based on the data set we have, and our definition of CU – the ratio of optimal to real level of fixed assets – gives us the possibility to distinguish between firms exhibiting under-utilisation (excess) of capacity (CU<1), and over-utilisation (CU>1) of the existent capacity. We calculate also growth rates of fixed assets (GRFA) . The joint analysis of the CU and GRFA, and the type of correlation between the two concepts is meant to give us some more insight about basic features of the business environment like i.e. increasing/decreasing market demand or firms’ investment policy in fixed assets.

In line with the findings obtained in the previous chapter, the objective pursued in Chapter 3 was to add more evidence but connecting the new empirical evidence with the one in Chapter 2, from a different perspective. Several theoretical hypothesis were expected not to be rejected by the results, and they refer to the following aspects: first, as the growth in output was in average mainly explained by the variation in inputs usage we expect before hand, to find CU<1 (excess of capacity) as the dominant situation in most of the industries and countries. This would confirm the fact that firms are not using optimally their physical assets. Second, if there is growth in fixed assets, then we expect this rate to be greater when CU>1 than when CU<1. The intuition behind is that when CU>1 firms are in need of capacity so there is incentive to invest in fixed assets. Third, we also expect to find in most of the cases structural efficiency coefficients (SE) bellow unit. In other words, firms are facing cost inefficiency problems originated by the fixed assets endowment which they are not able to adjust in the short–run.

In **Chapter 4**, we analyse firms' performance but this time we do not approach neither technical efficiency via growth in output, nor the cost efficiency via inputs and capacity utilisation. We take as reference the variable profits of the firms, calculated following the balance sheet approach, and define a measure of efficiency based on them. We construct a benchmark profit efficient frontier in a non–parametric framework, with variable returns to scale, and consider all three possible orientations (input-output, input, and/or output) when measuring the distance to the frontier. The profit variable is defined as the difference between revenue (turnover) and cost (cost of the employees, material expenses, depreciation, and interest paid).

There are several aspects related to the methodology applied in this chapter, worthwhile to be pointed out. Our profit efficiency measure is constructed based on directional distance function concept rather than the usual distance function, commonly used in most applications. We define our profit efficiency measure as the normalised deviation between maximal and observed profits. The normalisation ensures the homogeneity of degree zero in prices, and is given by the value of the direction of inputs and output variables. This normalised deviation is called the Nerlovian profit efficiency (NPE), and can be decomposed into technical efficiency (TE) and allocative efficiency (AE) components. We focus here mainly on the NPE and for this reason present empirical findings only for this measure.

Another methodological contribution of this chapter refers to the fact that we estimate NPE coefficients maximising both unconstrained and constrained profit functions. The main constraints we add are on: credits, interests paid and fixed assets. There are few applications maximising constrained profit functions. Most of them use as constraints only the expenditures/credits and/or investment, and very often analyse agricultural farms.

Moreover, in our case, the constraints are built for every unit such that they will affect the frontier technology: the fact that they are binding (affect firms' profit efficiency) will be reflected by a shift inwards of the profit frontier. In other words, firms were not able i.e. to get more credits in order to reach the optimal profit frontier because of the binding credit constraints. In case of other related works, the constraints are defined for every unit without affecting the frontier technology.

Another important aspect is the fact that we link the credit constraints analysis to the literature on soft/hard budget constraints, first introduced by Kornai (1979, 1980) in the former socialist economies. A binding constraint is an evidence for firms facing hard budget constraints.

Apart from the NPE measure, we are interested to test as well several hypotheses. To this purpose we checked for the significance of several explanatory variables in determining the level of the firms' profit efficiency. The hypotheses we take up focus on the following aspects: (a) we expect the countries in transition economies to exhibit a much lower profit efficiency than the countries in the developed market economies; (b) the constraints on credit, interest paid, and fixed assets are expected to be binding in the sense that they increase firms' profit inefficiency. Moreover we expect this constraints to have a much stronger impact on the firms in transition economies. If these hypotheses turn out to be correct, then our results would sum up to the existing theoretical and empirical arguments which have been suggested to explain the output fall in transition countries like i.e.: credit restrictions and high interest rates; the elimination of soft budget constraints, slow advance of the private sector, or the collapse of exports.

The hardening of the budget constraints faced by the firms is of particular importance here because it would allow us to confirm another generally accepted reality that in the post communist period, soft budget constraints have been replaced by hard budget constraints. Evidence on binding credit constraints in the advanced market economies has also been found. Another hypothesis to be tested (c), takes up the influence of the different ownership forms on firms profit efficiency. The firms in our data set are grouped in three main categories, public, private, and other type, and the existent empirical evidence found up to now supports the idea that the private firms' performance is superior to the state – owned (public firms), and one of the reasons is that they are the firms that mostly invest in technology and structural reforms. Another variable of interest is (d) the size expressed by the number of employees. We would like to see if this factor is significant or not in explaining the differences in performance among firms.

Taking advantage of the results obtained in Chapter 3 we are also interested in the relationship between capacity utilisation degree and firms' profit inefficiency. We would expect an inverse relationship that is, the lower the degree of capacity utilisation the higher the inefficiency in profits. Finally, we check also for the statistical significance of the differences in profit efficiency observed across countries, both for the case of unconstrained and constrained profit functions.

In the General Conclusions section we discuss our findings, the eventual shortcomings of this investigation, the causes which are possibly underlying them, and some ideas to improve and add new dimensions to the results presented in this dissertation.

Chapter 1

The Construction of a European Industrial Database

1.1. General Information

The empirical analysis is based on a sample of 1379 international firms, extracted from the AMADEUS[2] database. Table 1 gives a detailed description of countries included and of the codification that is found throughout the whole thesis.

Table 1: Countries and codes

Country Name	Country Code
Belgium	B
Bulgaria	Bu
France	F
Italy	I
Netherlands	N
Romania	R
Spain	S

We have individual firm balance sheet and profit and loss statement data from 1995 to 1998. The data are end-year observations. The standard peer groups are extracted by industry. The split by industry is made according to the NACE Rev. 1 code, 4-digit level, as shown in Table 2[3].

[2] AMADEUS is a database containing company information (mainly financial data) about the top 150,000 public and private companies in Europe. All European companies are legally required to file their accounts at official government registries in their own country. This information is collected for Bureau van Dijk by 26 local information providers and presented on Amadeus in a standardized format. This format has been derived by Bureau van Dijk from the most common formats used for the presentation of accounts in Europe, according to European Union guidelines.

[3] NACE Rev. 1 code is an extension of the original NACE classification first published in 1970 by EUROSTAT. (January, 1970, Office Statistique des Communautés Européennes, Nomenclature générale des activités économiques dans les Communautés Européenne NACE 1970, Luxembourg). NACE Rev. 1 was created in 1990 on the basis of ISIC Rev. 3, the classification of industrial activities used by the UN. All countries in the EU are obliged to use the classification based on NACE Rev.1 when submitting industrial data to EUROSTAT (the European Statistical office). Many countries in Central and Eastern Europe have switched to NACE Rev. 1.

Table 2: Industry Sectors

Division	**Sector Code**	**Detailed Description**
17		Manufacturing of Textiles
	172	Textile Weaving
	175	Manufacturing of other Textiles
21		Manufacturing of Paper and Paper products
	211	Manufacturing of Pulp, Paper and Paperboard
24		Manufacturing of Chemicals and Chemical Products
	241	Manufacturing of Basic Chemicals
25		Manufacturing of Rubber and Plastic Products
	251	Manufacturing of Rubber Products
	252	Manufacturing of Plastic Products

The variables extracted from the balance sheet and profit and loss account are listed in Table 3.

Table 3: Description of the Accounting Variables and the Relationship among them

Balance Sheet		
	(1) Fixed Assets[4]	
	(1) = (2)+(3)+(4)	(2) Intangible Fixed Assets
		(3) Tangible Fixed Assets
		(4) Other Fixed Assets (incl. Financial Fixed Assets)
	(5)Shareholders Funds	
	(5) = (6)+(7)	(6) Capital
		(7) Other Shareholders Funds (incl. Reserves)
	(8) Financial Debt	
	(8) = (9)+(10)	(9) Long Term Debt
		(10) Loans

[4] Fixed Assets are shown net of depreciation.

	(11) Number of Employees	
Profit and Loss Account		
	(12) Operating Revenue / Turnover[5]	
	(13) Financial Expenses	
	(14) Material Expenses	
	(15) Cost of Employees	
	(16) Depreciation	
	(17) Interest Paid	

Concerning the correspondence between the national accounting format and the Amadeus format, there are three cases to consider:

Case 1: France and Belgium

Accounts of companies in each of these countries are fully comparable and it is possible to link the formats of French and Belgian companies with the format used on Amadeus.

Case 2: Italy, Spain and Netherlands

In these countries, companies may legally use any type of presentation of their accounts. The local information providers have designed national formats that can be linked with the Amadeus format.

Case 3: Bulgaria and Romania

The financial data are delivered by the local information providers using the standardized Amadeus format of accounts.

For the companies included in our database, several legal forms can be found, as listed in Table 4.

[5] The operating Revenue / Turnover figure includes Sales plus all other revenues linked to the normal operations of the company (e.g. stock variation or subsidies in some countries).

Table 4: Public and Private Companies Legal Forms

Country	Public Companies Legal Forms (Type 1)		Private Companies Legal Forms (Type 2)	
Belgium	**SA-NV**	Société Anonyme – Naamloze Vennootschap	**SPRL-BVBA:**	Société de Personnes à Responsabilité Limitée – Besloten Vennootschap met Beperkte Aansprakelijkheid
Bulgaria	**AD** **EAD**	Public Limited Company One Person Public Limited Company	**OOD** **EOOD**	Private Limited Company One Person Private Limited Company
France	**SA**	Société Anonyme	**SARL**	Societé à Responsabilité Limitée
Italy	**SPA**	Società per Azoni	**SRL**	Sociedà a Responsabilità Limitata
Netherlands	**NV-SA**	Naamloze Vennootschap - Société Anonyme	**BV**	Besloten Vennootschap (Societé de Personnes à Responsabilité Limitée)
Romania	**SA**	Joint Stock Company	**SRL**	Limited Liability Company
Spain	**SA**	Sociedades Anónimas	**SL**	Sociedades Limitadas

The breakdown of the companies in each country according to the categories of legal forms described above, is given hereafter in Table 5. As figures indicate, the bulk of the companies are of type 1 (public) while only 10% of them are of type 2 (private).

Table 5: Breakdown of Companies per Categories of Legal Forms

Country	**Type 1**	**Type 2**	**Other forms**	***Total***
Belgium	148	1	0	***149 (11%)***
Bulgaria	29	0	2	***31 (2%)***
France	222	8	58	***288 (21%)***
Italy	371	101	1	***473 (34%)***
Netherlands	16	13	0	***29 (2%)***
Romania	247	13	0	***260 (19%)***
Spain	147	1	1	***149 (11%)***
Total	***1180 (85.5%)***	***137 (10.0%)***	***62 (4.5%)***	**1379**

If one considers the tradability of shares and the liability of the shareholders, the distinction between the two types of companies could be stated as follows[6]:

Type 1:
A company whose capital is divided into shares that can be offered to the general public and whose members are only liable for its debts to the extent of any amount unpaid on their shares.

Type 2:
A company whose capital is divided into shares which cannot be offered to the general public. The liability of its members is limited to the amount of their shares.

These distinctive features could be particularly helpful when explaining our empirical findings in Chapter 4, where we treat the issue of credit constraints and their impact on firms productive efficiency. In general, type 2 companies (SRL or assimilated) are more likely to have restrictive access to the credit market. Hence, a priori, one would expect them to face more binding budget constraints than type 1 companies (SA or assimilated).

1.2. Detection and Treatment of the Influential and Extreme Observations

The original data, extracted from Amadeus database, were expressed in thousands of dollars in international current prices (except for the number of employees). The data finally used for analysis are expressed in thousands of dollars and constant prices for 1995. For every group and country the data have been corrected with the corresponding Producer Price Indices (PPIs) on domestic market – annual data (1995 = 100) – as follows:

- for the EU countries – Belgium, France, Italy, Spain – the PPIs have been supplied by Eurostat[7] office, Madrid.

[6]Classification and definition according to Amadeus' database authors.
[7]Eurostat datashop Madrid, INE, Paseo de la Castellana, 183, 28046-Madrid. E-mail: datashop.eurostat@ine.es.

- For Bulgaria, the PPIs have been supplied by the National Statistics Institute-Sofia.
- For Romania, PPIs have been calculated using information on Industrial Production Price Indices for domestic market, reported by the National Commission for Statistics in the Romanian Statistical Yearbooks: 1997 - p. 434, 1998 – p. 398 and 1999 – p. 384.

Producer Price Indices from 1995 to 1998 per country and industry are reported in Appendix 1, at the end of this chapter. We discarded an additional correction of the data with purchasing power parities (PPPs). We consider that the analysis of productivity is more producer-oriented. Hence, we try to control for the movements in prices (PPI) in order to quantify the movements in real production. If there are differences in productivity across countries we are interested to capture and quantify them, and PPPs could eventually contribute to the homogenisation of these differences.

A good example for this approach, is the seminal work of Färe et al. (1994). The authors are applying Malmquist indexes to compare growth in productivity in a sample of 17 OECD countries over the period 1979-1988. They work with data from the Penn World Tables were the international prices are average world prices of final goods, rather than prices of a specific benchmark country. Verspagen (1995), concentrates on the relationship between technical change in the form of cumulated R&D investment and the growth rate of value added. The author provides empirical evidence for 16 sectors from 8 OECD countries over the period 1973-1988. The price data employed are various: producer prices are used to deflate value added; price index for investment is assumed to be equal across sectors, but not across countries, and is taken from the Penn World Tables; and R&D investment is deflated by the GDP deflator. Another example is Sueyoshi (1994), who applies stochastic frontier production analysis for measuring and predicting the performance of public telecommunications in 24 OECD countries in 1987. The data on input and output variables are all expressed in US dollars. And the list could continue.

The final sample contains 1379 companies covering a complete time horizon of 4 years. Some observations were discarded because some data were missing for one or more years, or for some of the variables extracted. Greene (2000) mentions two possible cases depending on why the data are missing. The first case is that the data are simply unavailable and this unavailability is unrelated to the rest of the observations in the sample being complete. Griliches (1986) refers to this as the *ignorable case* given that the complete observations in the sample constitute a usable data set, and the problem reduces to what possibly helpful information could be maintained from the incomplete data set.

A second case occurs when the missing data are systematically related to the phenomenon being analysed. As mentioned by Greene, this situation is very common when the data are self-selected. The author gives as example a survey designed to study expenditure patterns where if high-income individuals i.e. tend to withhold information about their income, the gaps in the data set would represent more than just missing information, limiting the inference of results to the whole population. Greene refers to this as the problem of *censored data* that is values in a certain range are all transformed to (or reported as) a single value, and is essentially considered a defect in the sample data. Going back to the income survey example, instead of being unobserved, incomes below the poverty line are reported as if they were *at* the poverty line. The censoring problem is treated in the econometrics literature as a particular case of truncation called *sample selection problem.*

The solution commonly applied is the estimation of a *censored normal regression model* or the so-called *tobit model*, first proposed by Tobin (1958). According to Maddala (1992) tobit model has some limitations: what we have in the model is a situation where a given variable can, in principle, take on negative values which we do not observe because of censoring. This means that the zero values are due to nonobservability. This is nevertheless not always the case because variables like i.e. hours worked, wages, number of employees cannot, in principle, assume negative values. The zero values are due not to censoring, but rather due to the decisions of individuals. Maddala considers that in this case the appropriate procedure would be to model the decisions that produce the zero observations and apply the tobit model only in those cases where the latent variable can, in principle, take negative values.

In our case, as the database is build upon company information collected on a survey basis, it is very likely that the respondents simply failed to answer the questions. This conclusion is supported by the fact that missing information occurs on random variables, and more of that the variables involved cannot take negative values. About 49 observations were identified as outliers. We briefly describe hereafter the outlier and influential observation concepts and the tools used for detecting and examining their role in frontier analysis.

According to Gunst and Mason[8] (1980), outliers are observations that "*do not fit in with the pattern of the remaining data points and are not at all typical of the rest of the data*". Wilson (1995) speaks about *influential observations* and defines them as "*those sample observations which play a relatively large role in determining estimated efficiency scores for at least some other observations in the observed sample*". In other words, influential observations are those observations which have a greater impact on the parameters estimated. Normally, we would expect outliers to be at the same time influential observations, but this may not always be true.

Most of the techniques proposed in the outlier literature identify the observations which deserve a closer scrutiny to determine whether they are correctly recorded or whether these are data errors. In the case of a simple regression, we can e.g. detect outliers simply by plotting the data. However, in the case of multiple regression such plotting would not be possible, and usually the problem is detected analysing the residuals from the estimated regression equation (see Wilson (1995) and Kerstens (1996) for a complete overview of the standard methods).

The technique we use to identify outliers is the one proposed by Andersen and Petersen (1993) and Lovell et al. (1993). They suggest a modification to the Data Envelopment

[8] As cited in Wilson (1995), p. 27.

Analysis (DEA) model to allow ranking of ostensibly efficient observations. Usually, the efficiency for the *i*th unit is estimated relative to all units in the sample, including the *i*th unit. The modification proposed involves removing the *i*th unit under evaluation from the definition of the technology constraints when efficiency for the *i*th unit is computed. The interpretation of the modified score for the *i*th unit doesn't change, except for the case when is ≥1. In such a case, the score would represent the amount by which the input vector for unit *i* may be proportionately increased without being dominated by a linear combination of the remaining units in the sample.

The technique is robust, the only case when the score cannot be estimated may occur when the unit lies above the frontier supported by the other units in the sample. In a situation like this, neither radial contractions nor expansions in inputs, holding output constant, would help to reach the frontier. Nevertheless, the authors of the technique indicate that this problem can be avoid by using the constant returns to scale setting. In spite of its robustness there are still some aspects which have to be taken with care. Wilson (1995) stress the fact that for methods like DEA, which measure efficiency relative to a deterministic frontier supported by the units in the sample, any measurement error will affect the efficiency scores. In other words, the method helps to identify and prioritise the units in the efficient subset but the final decision has to be taken if possible, considering all available information about the data, in order to determine the influence of a particular observation unit.

With a radial distance measure – Farrell (1957) – we calculate "superefficiency" scores using the above mentioned technique. The variables used are turnover for the output, and fixed assets, number of employees and material expenses for the inputs, all (except for the employees) expressed in constant 1995 prices. We apply the modified DEA model for both variable and constant returns to scale, and output orientation settings in order to avoid any situation of infeasibility in the computation of the scores. The breakdown score to identify possible outliers was established around 0.5, and 49 units were found to be outside this restriction. In most of the cases the units identified as outliers with variable returns to scale formulation, resulted also to be candidates for outliers with constant returns to scale setting. We finally decided to remove all the outliers from the sample as there was no other independent source of information available in order to examine and correct the data.

The initial structure of the database – 1428 units - is presented in Table 6 and the final structure, consisting of 1379 firms, with the outliers indicated in brackets is given in Table 7. As a general remark, it is interesting to point out that in most of the cases the outliers are mainly distributed among the developed countries and very few of them belong to the transition countries, Bulgaria and Romania respectively.

Table 6: Initial Structure of the Database

Country	Sector 172	Sector 175	Sector 211	Sector 241	Sector 251	Sector 252
Belgium	21	30	10	39	4	50
Bulgaria	8	3	4	7	2	7
France	27	23	37	65	44	109
Italy	59	54	58	97	44	178
The Netherlands	-	5	8	9	3	9
Romania	48	38	12	57	31	75
Spain	10	17	30	19	16	61
Total Sector	**173**	**170**	**159**	**293**	**144**	**489**
Total General	**1428**					

The results are to a great extent explained by the use of *superefficiency* concept to identify outliers. This technique requires that the observation units have to be efficient, i.e. perform on the frontier. Most of the efficient observation units belong, as expected, to the advanced market economies. Hence, the number of outliers from these countries will be automatically greater. Another explanation could be related to the *size* of the units analysed. We control for this parameter working in a VRS setting and moreover, DEA is a method which builds on ratios (relative terms). Nevertheless, there is an open debate in the literature on whether it is more appropriate to work with original data or take logarithms. We do not deal with this issue here, but this approach could be actually a good topic for a future analysis. Finally, in the case of Bulgaria it is also true that the number of observation units in all industry sectors is overall rather low. For Romania, there is one outlier identified and it belongs to the largest number of units representing this country in the database (sector 252 – 74 units).

Table 7: Final Structure of the Database – Outliers Excluded Indicated in Bold

Country	Sector 172	Sector 175	Sector 211	Sector 241	Sector 251	Sector 252
Belgium	20 (**1**)	29 (**1**)	9 (**1**)	38 (**1**)	4	49 (**1**)
Bulgaria	8	3	4	7	2	7
France	25 (**2**)	22 (**1**)	33 (**4**)	62 (**3**)	41 (**3**)	105 (**4**)
Italy	57 (**2**)	52 (**2**)	55 (**3**)	93 (**4**)	43 (**1**)	173 (**5**)
Netherlands	-	4 (**1**)	6 (**2**)	8 (**1**)	3	8 (**1**)
Romania	48	38	12	57	31	74 (**1**)
Spain	10	17	30	19	15 (**1**)	58 (**3**)
Total Sector	**168**	**165**	**149**	**284**	**139**	**474**
Total General	**1379**					

In spite of the outliers identified here, in some very few cases, due may be to the complexity of the computations and to the particular features of every methodology applied in each chapter, we still could determine few more infeasible units. When this is the case, they are properly mentioned.

In Appendix 1 we present for every industry sector and year descriptive statistics for input and output variables: mean, standard deviation, maximum and minimum values, skewness and kurtosis. The information is reported both for the sample with and without outliers. The distributions have shifted downwards between years indicating that the outliers are mainly found among the large units.

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Producer Price Indices – annual data (1995 = 100)

Code NACE Rev. 1 and Industry	Country	1995	1996	1997	1998
17 Manufacturing of Textiles	Belgium	100.00	96..30	95..95	95.72
	Bulgaria	100.00	214.08	2180..29	2421.92
	France	100.00	99.03	100.05	97.72
	Italy	100.00	101.36	101.72	102.84
	Netherlands	100.00	97.80	98.98	97.96
	Romania	100.00	150.40	320.65	444.88
	Spain	100.00	100.89	101.31	103.04
21 Manufacturing of Pulp, Paper and Paper Products	Belgium	100.00	98.25	97.08	99.09
	Bulgaria	100.00	182.86	1868.38	2079.46
	France	100.00	92.92	89.45	90.83
	Italy	100.00	90.01	85.53	86.47
	Netherlands	100.00	97.03	93.82	94.38
	Romania	100.00	141.71	317.00	399.05
	Spain	100.00	88.44	86.34	87.43
24 Manufacturing of Chemicals and Chemical Products	Belgium	100.00	98.11	98.66	98.08
	Bulgaria	100.00	216.64	2321.85	2821.23
	France	100.00	98.64	98.92	97.67
	Italy	100.00	98.07	100.11	98.58
	Netherlands	100.00	97.70	102.20	97.70
	Romania	100.00	146.71	370.00	467.12
	Spain	100.00	98.20	100.14	96.86
25 Manufacturing of Rubber and Plastic Products	Belgium	100.00	100.05	99.58	99.70
	Bulgaria	100.00	238.60	2486.64	2506.27
	France	100.00	98.38	97.22	95.60
	Italy	100.00	101.42	100.14	100.26
	Netherlands	100.00	98.60	98.80	98.90
	Romania	100.00	151.53	330.64	409.28
	Spain	100.00	100.62	101.55	101.34

Appendix 1

Descriptive Statistics on the Data per Sector

Except for the Employees, the rest of the variables represent thousands of dollars, 1995 constant prices

Sector 172 – Textile Weaving

Initial number of firms - 173

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	7306.32	477.21	18848.58	35423.34
Standard Deviation	9712.78	642.28	40529.07	58139.96
Maximum Value	70449.00	4602.00	480428.00	560656.00
Minimum Value	58.00	9.00	94.00	227.00
Skewness	3.40	2.73	8.97	5.57
Kurtosis	14.75	10.69	98.92	42.33

Final number of firms – 168 (Excluding Outliers)

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	7277.85	486.64	16294.48	32453.36
Standard Deviation	9825.51	648.81	20078.23	42565.57
Maximum Value	70449.00	4602.00	127558.00	329097.00
Minimum Value	58.00	9.00	94.00	227.00
Skewness	3.39	2.69	2.82	3.46
Kurtosis	14.50	10.39	10.02	16.88

Initial number of firms - 173

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	6375	480	17146	33813
Standard Deviation	9664	630	40043	58820
Maximum Value	61492	4587	485059	571189
Minimum Value	38	4	132	261
Skewness	3	3	10	6
Kurtosis	11	11	110	43

Final number of firms – 168 (Outliers excluded)

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	6434	491	14593	30881
Standard Deviation	9788	636	18155	42664
Maximum Value	61492	4587	98481	315153
Minimum Value	38	8	132	261
Skewness	3	3	2	3
Kurtosis	11	11	7	14

Initial number of firms - 173

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	5366.66	463.86	16247.81	31147.19
Standard Deviation	8469.24	599.33	38502.25	54871.34
Maximum Value	47421.57	4272.00	467302.35	544088.96
Minimum Value	45.45	9.00	48.65	91.27
Skewness	2.76	2.68	9.64	5.88
Kurtosis	8.24	10.29	110.74	47.33

Final number of firms – 168 (Outliers Excluded)

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	5273.34	472.56	13754.11	28204.83
Standard Deviation	8463.63	605.38	17279.58	38853.66
Maximum Value	47421.57	4272.00	105472.87	293002.50
Minimum Value	45.45	9.00	48.65	91.27
Skewness	2.82	2.64	2.57	3.35
Kurtosis	8.60	10.00	8.52	16.03

Initial number of firms - 173

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	5751.99	413.41	17696.01	34087.39
Standard Deviation	8817.08	500.06	43571.75	62322.01
Maximum Value	49327.67	2585.00	527106.02	615604.79
Minimum Value	34.06	9.00	25.62	67.21
Skewness	2.45	2.26	9.59	5.99
Kurtosis	6.29	5.52	109.83	48.18

Final number of firms – 168 (Outliers Excluded)

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	5575.12	420.54	14915.35	30798.93
Standard Deviation	8722.40	504.88	19732.60	44247.48
Maximum Value	49327.67	2585.00	124512.89	365546.46
Minimum Value	34.06	9.00	25.62	67.21
Skewness	2.55	2.22	2.56	3.70
Kurtosis	6.89	5.32	8.21	20.76

Sector 175 – Manufacturing of other Textiles

Initial number of firms - 170

1995	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	28604.97	567.71	42569.82	91133.31
Standard deviation	219386.89	1582.05	214629.88	498426.59
Maximum Value	2840314.00	17783.00	2733732.00	6360633.00
Minimum Value	15.00	5.00	31.00	110.00
Skewness	12.62	8.31	11.86	11.97
Kurtosis	162.37	84.77	148.58	150.51

Final number of firms – 165 (Outliers Excluded)

1995	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	12177.96	462.75	26718.55	53041.78
Standard deviation	33235.62	863.99	55003.13	120578.29
Maximum Value	242895.00	5860.00	395849.00	843555.00
Minimum Value	15.00	5.00	31.00	110.00
Skewness	5.60	4.12	4.58	5.07
Kurtosis	33.00	20.47	23.37	27.96

Initial number of firms - 170

1996	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	28923.80	568.18	41014.97	88350.53
Standard Deviation	243904.89	1598.43	218308.84	486212.26
Maximum Value	3167880.37	18025.00	2795500.00	6210266.87
Minimum Value	24.24	9.00	22.61	114.36
Skewness	12.77	8.39	12.07	12.01
Kurtosis	165.14	86.00	152.39	151.12

Final number of firms – 165 (Outliers Excluded)

1996	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	10525.16	461.38	24760.29	51181.82
Standard Deviation	29433.45	864.98	50540.56	115800.57
Maximum Value	238793.46	6014.00	381177.91	834486.71
Minimum Value	34.69	9.00	22.61	114.36
Skewness	6.03	4.18	4.59	5.10
Kurtosis	39.74	20.91	24.37	28.72

Initial number of firms - 170

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	24469.59	570.98	40995.93	85910.78
Standard Deviation	208091.24	1619.38	234380.11	497772.28
Maximum Value	2703061.22	18135.00	3016591.23	6383273.39
Minimum Value	22.72	8.00	5.61	64.24
Skewness	12.78	8.36	12.28	12.17
Kurtosis	165.27	84.47	156.25	154.06

Final number of firms – 165 (Outliers Excluded)

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	8763.46	463.28	23406.89	47749.71
Standard Deviation	24756.05	891.35	47778.02	108736.86
Maximum Value	198853.30	7374.00	337652.05	841208.32
Minimum Value	22.72	8.00	5.61	64.24
Skewness	5.94	4.81	4.49	5.19
Kurtosis	38.72	29.34	23.00	30.34

Initial number of firms - 170

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	30125.03	586.77	46287.72	99026.62
Standard deviation	268250.02	1925.45	273139.39	602058.86
Maximum Value	3489763.17	22576.00	3519489.59	7745902.41
Minimum Value	13.71	13.00	2.92	33.94
Skewness	12.85	9.48	12.33	12.30
Kurtosis	166.58	103.39	157.27	156.54

Final number of firms – 165 (Outliers Excluded)

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	9816.40	452.07	25705.44	52628.78
Standard deviation	27131.73	914.95	53438.05	120155.66
Maximum Value	228803.59	8657.00	390439.98	953704.57
Minimum Value	13.71	13.00	2.92	33.94
Skewness	5.95	5.83	4.39	5.09
Kurtosis	39.78	43.83	22.31	29.76

Sector 211 – Manufacturing of Pulp, Paper and Paper Products

Initial number of firms - 159

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	53524.47	662.08	112376.14	185185.68
Standard Deviation	228153.51	2483.24	544560.72	852487.96
Maximum Value	2346048.00	28629.00	5746073.00	9459611.00
Minimum Value	23.00	1.00	143.00	155.00
Skewness	8.62	9.71	9.05	9.48
Kurtosis	78.77	105.08	85.65	96.19

Final number of firms – 149 (Outliers Excluded)

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	29198.15	426.31	50225.82	92099.18
Standard Deviation	51578.58	665.81	83280.39	151626.44
Maximum Value	314700.00	3687.00	704148.00	1194859.00
Minimum Value	94.00	16.00	456.00	830.00
Skewness	3.36	2.96	4.56	4.01
Kurtosis	12.47	9.63	27.83	21.07

Initial number of firms - 159

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	51236.58	647.84	103198.07	169865.10
Standard Deviation	221817.42	2329.55	502612.26	773800.08
Maximum Value	2623218.59	26504.00	4907155.52	8049934.04
Minimum Value	25.83	1.00	61.34	778.74
Skewness	10.32	9.42	8.59	8.87
Kurtosis	116.88	99.69	75.52	82.39

Final number of firms – 149 (Outliers Excluded)

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	30320.39	429.83	45599.81	83800.25
Standard Deviation	55304.74	663.88	83894.73	139332.54
Maximum Value	387433.78	3931.00	699762.96	1150834.79
Minimum Value	54.34	16.00	509.49	778.74
Skewness	3.95	3.00	4.92	4.36
Kurtosis	19.02	10.18	30.40	25.43

Initial number of firms - 159

1997	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	42057.14	621.87	107500.72	172322.68
Standard Deviation	140727.49	2283.23	506428.51	767290.20
Maximum Value	1261798.12	27190.00	5258549.35	8335371.99
Minimum Value	19.87	1.00	117.38	229.08
Skewness	7.03	10.31	8.40	8.87
Kurtosis	53.23	117.99	76.56	86.68

Final number of firms – 149 (Outliers Excluded)

1997	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	30688.14	438.66	52788.41	93130.95
Standard Deviation	90942.58	778.38	171944.52	261411.12
Maximum Value	1042680.67	6932.00	2001243.87	3002203.15
Minimum Value	19.87	18.00	148.42	229.08
Skewness	9.57	5.02	10.12	9.58
Kurtosis	105.06	34.49	113.31	105.11

Initial number of firms - 159

1998	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	38144.09	520.03	112591.74	174890.07
Standard Deviation	120295.21	1516.09	518951.52	711535.37
Maximum Value	1285815.85	16986.00	5348780.46	7302613.90
Minimum Value	8.10	1.00	123.31	226.79
Skewness	8.15	8.85	8.23	8.10
Kurtosis	77.32	90.93	73.82	71.80

Final number of firms – 149 (Outliers Excluded)

1998	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	33065.76	403.05	58118.40	102573.13
Standard Deviation	108989.73	697.74	201184.45	299397.27
Maximum Value	1285815.85	6959.00	2370042.38	3475383.56
Minimum Value	14.53	18.00	144.34	226.79
Skewness	10.46	6.17	10.49	9.90
Kurtosis	119.84	52.91	119.82	110.44

Sector 241 – Manufacturing of Basic Chemicals

Initial number of firms - 293

1995	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	59107.61	845.11	77236.88	159285.54
Standard Deviation	221565.67	2631.61	231400.20	526485.31
Maximum Value	2840314.00	36809.00	2733732.00	6360633.00
Minimum Value	60.00	5.00	195.00	629.00
Skewness	8.72	10.05	7.59	8.20
Kurtosis	93.75	125.81	71.01	80.21

Final number of firms – 284 (Outliers Excluded)

1995	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	47686.43	789.08	62104.95	118907.12
Standard Deviation	148890.60	2465.34	150096.96	305477.30
Maximum Value	1483255.00	36809.00	1581576.00	3586018.00
Minimum Value	60.00	5.00	195.00	629.00
Skewness	6.56	11.52	6.40	7.68
Kurtosis	49.21	162.68	51.13	74.12

Initial number of firms - 293

1996	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	55966.36	815.73	81586.55	154958.86
Standard Deviation	226363.21	2543.84	301009.01	518354.87
Maximum Value	3171123.85	36387.00	3623390.44	6216623.34
Minimum Value	60.14	5.00	76.16	114.01
Skewness	10.17	10.66	8.83	8.17
Kurtosis	127.63	138.28	89.81	79.42

Initial number of firms - 284

1996	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	43297.18	757.39	58907.10	114274.74
Standard Deviation	131735.68	2360.70	147470.63	288726.70
Maximum Value	1285516.26	36387.00	1468859.44	3197034.96
Minimum Value	67.39	5.00	76.16	114.01
Skewness	6.31	12.45	6.28	7.10
Kurtosis	46.29	184.72	47.62	63.38

Initial number of firms - 293

1997	Fixed assets	No. of Employees	Material Expenses	Turnover
Mean	44614.77	771.49	76806.19	141834.00
Standard Deviation	182442.84	2529.43	296388.48	497354.57
Maximum Value	2617897.26	36575.00	3505095.40	6182156.56
Minimum Value	15.29	5.00	21.10	31.57
Skewness	10.60	11.05	8.96	8.59
Kurtosis	138.94	145.39	91.31	88.29

Final number of firms – 284 (Outliers Excluded)

1997	Fixed assets	No. of Employees	Material Expenses	Turnover
Mean	34106.06	710.95	54146.23	102269.28
Standard Deviation	100502.84	2340.09	138966.60	261186.11
Maximum Value	960726.74	36575.00	1353821.20	2659875.33
Minimum Value	15.29	5.00	21.10	31.57
Skewness	5.79	13.01	6.20	6.86
Kurtosis	39.09	196.55	45.45	57.92

Initial number of firms – 293

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	50111.19	732.22	73676.80	146311.79
Standard Deviation.	229253.20	2588.86	262178.00	536323.08
Maximum Value	3499050.15	35990.00	3528855.68	7766515.86
Minimum Value	12.94	5.00	14.21	4.15
Skewness	12.24	10.90	9.47	10.81
Kurtosis	177.53	135.22	110.19	143.09

Final number of firms – 284

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	37008.13	655.27	55509.14	107667.89
Standard Deviation	107454.77	2273.58	140265.23	265267.97
Maximum Value	887749.80	35990.00	1295939.50	2683193.31
Minimum Value	12.94	5.00	14.21	4.15
Skewness	5.31	13.54	6.51	6.54
Kurtosis	31.21	208.00	49.89	52.52

Sector 251 – Manufacturing of Rubber Products

Initial number of firms - 144

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	28675.67	1028.73	59430.46	124780.70
Standard Deviation	137894.47	3163.70	221668.87	477122.45
Maximum Value	1501074.00	27766.00	1725783.00	4053919.00
Minimum Value	21.00	19.00	88.00	227.00
Skewness	9.23	6.70	6.40	6.68
Kurtosis	94.07	49.88	43.15	47.89

Final number of firms – 139 (Outliers Excluded)

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	25211.96	863.31	49248.49	99472.46
Standard Deviation	131571.66	2266.75	178428.40	350810.13
Maximum Value	1501074.00	22375.00	1725783.00	3387334.00
Minimum Value	21.00	23.00	88.00	227.00
Skewness	10.50	7.04	7.45	7.31
Kurtosis	117.01	61.03	62.09	60.91

Initial number of firms - 144

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	28030.58	1025.64	56223.14	123267.55
Standard Deviation	135782.20	3081.29	216121.62	480514.52
Maximum Value	1452868.15	27168.00	1681886.56	4110141.29
Minimum Value	24.40	15.00	54.77	226.36
Skewness	8.88	6.65	6.45	6.72
Kurtosis	88.01	49.46	43.88	48.47

Final number of firms – 139 (Outliers excluded)

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	24571.48	864.24	45919.86	97562.21
Standard Deviation	129385.30	2198.77	170512.47	350851.76
Maximum Value	1452868.15	21458.00	1648081.14	3389562.88
Minimum Value	24.40	25.00	54.77	226.36
Skewness	10.10	6.83	7.43	7.32
Kurtosis	109.88	57.97	61.96	61.07

Final number of firms - 144

1997	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	25612.94	1005.63	52704.87	114180.20
Standard Deviation	129961.63	3056.25	201715.86	447146.96
Maximum Value	1368052.63	27078.00	1608318.25	3844118.49
Minimum Value	21.60	11.00	25.58	65.39
Skewness	8.77	6.74	6.45	6.73
Kurtosis	84.55	50.52	44.02	48.78

Final number of firms – 139 (Outliers Excluded)

1997	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	21543.56	843.98	42824.02	90097.75
Standard Deviation	120266.45	2168.65	156423.40	324831.79
Maximum Value	1368052.63	21361.00	1497056.68	3132013.16
Minimum Value	26.31	25.00	25.58	65.39
Skewness	10.45	7.00	7.31	7.31
Kurtosis	116.14	60.30	59.90	60.75

Initial number of firms - 144

1998	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	27587.64	956.44	60988.02	131791.48
Standard Deviation	136914.36	3001.00	231166.88	519467.12
Maximum Value	1392740.14	26828.00	1978768.83	4735713.39
Minimum Value	15.69	13.00	27.12	70.61
Skewness	8.39	6.83	6.50	6.92
Kurtosis	76.57	51.63	45.61	52.82

Final number of firms – 139 (Outliers Excluded)

1998	**Fixed Assets**	**No. of Employees**	**Material Expenses**	**Turnover**
Mean	22635.43	794.74	48701.42	101819.41
Standard Deviation	122730.98	2105.80	168788.70	353225.69
Maximum Value	1392740.14	20697.00	1525855.41	3239555.11
Minimum Value	32.74	33.00	27.12	70.61
Skewness	10.37	7.11	6.75	6.81
Kurtosis	114.79	60.83	50.52	52.14

Sector 252 – Manufacturing of Plastic Products

Initial number of firms- 489

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	14613.49	387.79	27756.45	52757.68
Standard Deviation	71957.51	1160.21	88473.84	173729.22
Maximum Value	1501074.00	22375.00	1725783.00	3387334.00
Minimum Value	33.00	1.00	16.00	227.00
Skewness	18.39	14.49	15.25	15.22
Kurtosis	375.45	265.91	281.54	281.05

Final number of firms – 474 (Outliers Excluded)

1995	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	11280.43	338.28	22449.26	43016.14
Standard Deviation	24559.21	588.58	36141.31	77865.68
Maximum Value	242895.00	4780.00	395849.00	843555.00
Minimum Value	46.00	2.00	59.00	227.00
Skewness	6.51	3.93	5.52	6.32
Kurtosis	51.33	18.42	41.90	49.53

Initial number of firms - 489

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	14059.41	392.39	24630.05	49553.86
Standard Deviation	69596.62	1123.44	83516.49	171901.01
Maximum Value	1452868.15	21458.00	1648081.14	3389562.88
Minimum Value	12.57	4.00	23.38	145.85
Skewness	18.45	14.09	15.78	15.72
Kurtosis	376.73	254.92	296.04	294.94

Final number of firms– 474 (Outliers Excluded)

1996	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	10746.66	345.05	19982.41	40463.20
Standard Deviation	23235.91	586.16	33539.23	75317.90
Maximum Value	271443.05	4733.00	378085.19	827716.02
Minimum Value	12.57	5.00	49.50	145.85
Skewness	7.06	3.88	5.96	6.61
Kurtosis	63.32	17.91	48.23	54.01

Initial number of firms - 489

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	12210.24	385.09	23290.09	46051.89
Standard Deviation	64749.35	1103.97	75836.86	158029.01
Maximum Value	1368052.63	21361.00	1497056.68	3132013.16
Minimum Value	4.79	5.00	9.69	28.87
Skewness	19.08	14.57	15.72	15.89
Kurtosis	396.31	268.54	295.46	300.64

Final number of firms – 474 (Outliers Excluded)

1997	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	9106.82	337.72	19066.17	37714.44
Standard Deviation	19141.27	553.41	30446.56	67873.48
Maximum Value	211572.62	4000.00	308480.77	696238.87
Minimum Value	4.79	6.00	9.69	28.87
Skewness	6.57	3.76	5.37	6.34
Kurtosis	54.54	16.35	39.43	49.64

Initial number of firms - 489

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	14526.41	371.30	35172.05	53055.32
Standard Deviation	69715.53	1065.69	96998.06	170245.67
Maximum Value	1392740.14	20697.00	1525855.41	3239555.11
Minimum Value	4.75	4.00	16.61	45.88
Skewness	16.61	14.77	9.75	14.29
Kurtosis	317.55	272.93	125.65	254.43

Final number of firms – 474 (Outliers Excluded)

1998	Fixed Assets	No. of Employees	Material Expenses	Turnover
Mean	11391.17	326.40	30287.04	44221.87
Standard Deviation	30108.92	525.86	64362.37	83882.51
Maximum Value	451125.52	4453.00	732206.07	740462.08
Minimum Value	4.75	7.00	16.61	45.88
Skewness	8.94	4.18	6.93	5.93
Kurtosis	107.46	21.43	58.78	40.47

Chapter 2

Output Growth and Explanatory Factors: Productivity and Growth in Inputs[9]

2.1. Introduction

This chapter focuses on the growth in output registered in period 1995-1998 in each of the six industrial sectors presented in chapter 1, and its main objective is to determine which are the substantial contributing factors. We approach the study of the output performance of the firm from the perspective of productivity and efficiency analysis.

For this purpose we develop a non-parametric methodology for calculating productivity growth which merges ideas from measurement of efficiency by Farrell (1957), and from measurement of productivity as expressed by Aly and Grabowski (1988), Prior (1990) and Färe, Grosskopf, Lindgren and Roos (1992). The starting point of this approach is the construction of a best practice production frontier allowing for the measurement of technical change (shifts in the frontier). Technical efficiency is then calculated, for each observation unit (firm), as the distance between the frontier and the observed output (catching up effect). Total factor productivity growth (TFP) measure is finally obtained by summing up temporal changes in efficiency and technical change.

TFP is thus regarded as the consequence of two rather different factors. On the one hand, the adoption of technical innovations in processes and products, shifting the production frontier upwards, is measured by the technical change. On the other hand, technical

[9] Preliminary versions of this chapter have been presented in seminars at the Centre for Industrial Economics, Copenhagen 1998, the 13th IAE Symposium Barcelona 1998 and the 2nd CEPR/CEU Annual Transition Economics Summer Workshop for Young Academics, Budapest 1999.

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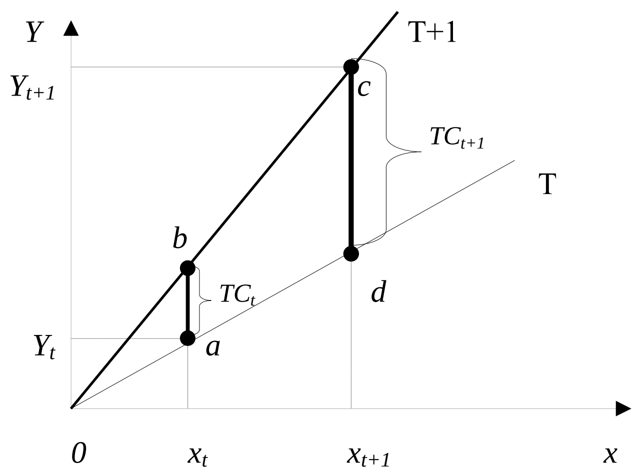
efficiency change reflects the capacity of firms to improve production with given inputs and available technology.

The methodology we apply here allows us not only to distinguish the contribution of the two above mentioned factors to TFP, but it offers an important added dimension to measure temporal technical changes. In Figure 1 below, we give the intuition in a constant returns to scale (CRS) technology setting while the formal presentation is presented in the next sections.

Let us consider, for the same observation unit, two measures of the output level at two consecutive moments in time, t and t+1. That is, points $a(y_t, x_t)$ and $c(y_{t+1}, x_{t+1})$ respectively, where *y* stands for output and *x* for input. Moreover, for simplicity, our observation unit performs already on the frontier both at moment t and t+1. Later on, we will formally define and refer to such units as being *efficient*.



TC – technical change

Figure 1. The Measurement of Technical Change

If want to analyse the variation in output for our observation unit, graphically the movement from *a* to *c*, we have two alternatives: (1) take as reference the T+1 frontier (*abc*) or (2) consider instead the frontier at moment T (*adc*). Although the two alternatives give the same output variation they differ in essence in the way they measure the technical change.

As defined before, technical change represents the shift in the production frontier from T to T+1, measured at the frontier level. As it can be seen from the figure, in the first case (*abc*) technical change is given by the vertical distance |*ab*|. That is, it is measured at moment *t*, and will be referred as *technical change with initial year data* . The remaining distance |*bc*|, represents the variation in output due to input changes and it is measured taking as a benchmark the frontier T+1.

In the second case (*adc*), technical change it is measured at the end of the period (t+1) being given by the distance |*dc*|, and will be called *technical change with final year data*. In this case, the variation in output explained by the change in inputs is given by the distance |a*d*|, and frontier T is taken as reference. There is also a third alternative for measuring the variation in output from *a* to *c,* which consists of *averaging* the results of the two previous alternatives.

The model applied in this chapter allows us to measure technical change with final and initial year data. Moreover, the output growth rate can be broken down in three main components: a) growth due to improvements in technical efficiency (catching up to the frontier); b) growth due to technical change (shifts in the frontier) and, c) growth explained by a greater inputs usage (movements along the same production frontier).

Another contribution of this chapter is related to the measurement of scale effects. That is, we identify the presence of scale effects taking as reference the variation in inputs. The intuition is as follows: input changes calculated relative to the variable returns to scale (VRS) technology can be decomposed into input changes calculated relative to the CRS technology and a scale effects component (captures changes in the deviation between the VRS and CRS technology). In the line with the methodology applied to measure technical change, we determine scale effects both with final and initial year data.

Most of the cases that calculate scale efficiency identifying deviations from returns to scale, take as reference the technical efficiency change component rather than input changes. In this line we can mention the work of Färe et al. (1994), where the authors calculate the Malmquist index relative to the CRS technology. Next, they take the efficiency-change component calculated relative to CRS technology and decomposes it into a pure efficiency-change component (calculated relative to the VRS technology) and a residual scale component. In the same line, Domazlicky and Weber (1997), in a non-parametric framework and output orientation, also decompose the technical efficiency change into pure technical efficiency and scale efficiency.

We perform the computation of results for every sector over the period 1995 to 1998. Initially, we calculated the decomposition of the output growth rate for every year (1995-96, 1996-97, 1997-98), but the variations observed from one year to another were not relevant. This was somehow expected given that the effects of technical progress are more likely to be observed in the mid- long-run. Apart from this, we wanted to avoid an excessive repetition of similar results given the dimension of the database. For this reason, we present the results of the output growth decomposition for the period 1995-1998. We also do not show results for every firm in a given sector but rather present global means for each sector instead.

We construct a best practice frontier based on the data for all the firms in a sector and compare each firm in that sector with the best practice frontier of the sector. We conduct our calculations in CRS and VRS technologies and output orientation. The chapter is organized as follows. In Section 2.2 we give a brief stylised summary of some of the recent works related to alternative explanations for the variations and the determinants of productivity growth. In section 2.3 we explain our proposal of decomposition for the growth in output. Section 2.4 reports in detail the empirical results. Section 2.5 concludes.

2.2. Determining the Efficient Frontier

When analysing the variations in output observed across countries, industrial sectors/firms and over time, we usually try to determine the explanatory factors of the output growth or slowdown and generally use the concepts of *efficiency* or *productivity* when describe the performance achieved. For the very simple case of one output and one input, the productivity of a production unit can be defined as the ratio of its output to its input. The variations in productivity are mainly due to differences in production technology, differences in the efficiency of the production process, and in the environment. Most of the studies on productivity focus on the isolation of the efficiency component and on the measurement of its contribution to productivity.

When speaking about efficiency, we could define it intuitively as the result of the comparison between observed and optimal values of the output and input of a production unit. When the optimum is defined in terms of production possibilities, the efficiency is technical. In contrast, we measure economic efficiency when compare observed and optimum i.e. cost, revenue or profit of the production unit, subject to the appropriate constraints on quantities and prices.

Koopmans (1951, p.60) gave a formal definition of technical efficiency: "*a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output*".

Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency defined as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given outputs. According to their definition, a score of unity would indicate technical efficiency while a score less than unity implies technical inefficiency. The Debreu – Farrell measure can be converted as well to equiproportionate output expansion with given inputs.

So, an efficiency measure quantifies a "distance" (whose formal definition is given in the next section) between the quantities of outputs and inputs considered, and the quantities defining the efficient frontier of the technology. This distance can be calculated in input-, output- and non-oriented versions. The input oriented measure calculates the input reduction which is necessary to become efficient holding the outputs constant. In contrast, an output oriented measure quantifies the output expansion holding the inputs constant, while a non-oriented measure deals with necessary improvements when both inputs and outputs can be adjusted simultaneously.

The choice of any of these measures mostly depends on interpretation criteria: (a) – the *primal* interpretation i.e. relates the meaning of the efficiency score to input and output quantities; (b) – the *dual* interpretation puts into relation the efficiency score with input and output prices, and (c) – the *axiomatic properties* of the efficiency measure like i.e. monotonicity, continuity or units invariance. Most of the measures are actually similar with respect to these criteria.

An important feature of Debreu-Farrell measure of technical efficiency is that is necessary but not sufficient for Koopmans technical efficiency, but on the other hand there is no such distinction between the definition and measure of *economic* efficiency that requires the specification of an economic objective and information on market prices. A complete analysis of these differences and the solutions proposed in the literature can be found in Färe et al. (1985).

2.3. Best Practice Frontier in a Non-Parametric Framework and the Distance Function

Farrell defined his measure of technical efficiency based upon a production frontier postulating the convexity of the production set. More recently, his work has been extended to three empirical methodologies: (1) - deterministic frontier analysis (DFA) (Aigner and Chu 1968) measures efficiency relative to a deterministic parametric frontier; (2) - stochastic frontier analysis (SFA) (Aigner, Lovell and Schmidt 1977, Meeusen and van den Broeck 1977) measures efficiency relative to a stochastic parametric frontier; and (3) - data envelopment analysis (DEA) (Charnes Cooper and Rhodes 1978) which measures efficiency relative to a deterministic non-parametric frontier. Each of these methodologies has its advantages and disadvantages that we are not going to analyse here, as they are very well pointed out by Lovell (1996).

The interpretation of productivity gains (or losses) is improved to a large extent with the introduction of the concept of production frontier and its shifts. The technical progress concept appears when a shift of the frontier occurs. This shift allows for two possible interpretations: as an increase in the output realised varying the quantities of inputs, or as a reduction of the minimal input quantities required for ensuring any level of output. The interpretation problem, to point out here, is how to distinguish shifts alongside the production frontier from shifts of the production frontier itself? The productivity concept cannot distinguish either of these two shifts.

Nevertheless, in the literature, three methods which we only mention here, have been developed: (a) the econometric estimation of production or cost functions; (b) a discrete approximation of the Divisia productivity index, and (c) the calculation of exact index numbers. Each of these methods is largely explained and discussed in Thiry and Tulkens (1989).

Overall, we could say that the relationship between productivity and technical progress is ambiguous, because productivity incorporates technical progress (when it occurs) without being able to identify its presence. In the same fashion the relationship between productivity and efficiency is characterised by a same type of ambiguity: it is not possible to distinguish between productivity variations implying efficiency variations, and those which do not. In both cases this is mainly due to the fact that the productivity concept does not make reference to the fundamental concept of production function, which allows such a distinction.

Aly and Grabowski (1988), using a parametric frontier approach, decomposed the output growth in (a) growth due to Total Factor Productivity (TFP)[10] change and (b) growth due to the increase in inputs usage. They also developed a methodology allowing to correctly distinguish between technical change and changes in technical efficiency in output growth. When applying the methodology to the case of Taiwanese agriculture they found that the growth in output was mainly explained by the increased inputs usage and the high level of technical efficiency rather than the technical change as shown by previous studies.

Caves, Christensen, and Diewert (1982) define an input based Malmquist productivity index as the ratio of two input distance functions, imposing overall efficiency by Farrell (1957) and a translog structure on the distance functions. The technique has been extended by Färe, Grosskopf, Lindgren, and Roos (1992, 1994), who without imposing any assumptions on technology define a Malmquist index of productivity which can distinguish between changes in efficiency and changes in the production frontier. In the same line goes the study of Färe, Grosskopf, Yaisawarng, Li, and Wang (1990), on U.S. electric utilities.

Farrell (and many hundreds of studies) applied his measure of overall efficiency to cross – sectional data which allows for a straightforward interpretation of the results, regardless of the methodology used. Nevertheless a cross-sectional analysis provides only a partial evaluation of a process which evolves through time. For this reason all methodologies – DFA, SFA and DEA – have recently been adapted to panel data. Forsund and Hjalmarsson (1979a, 1979b) were probable the first to apply DFA to panel data. Pitt and Lee (1981) and Schmidt and Sickles (1984) extended SFA to panel data, and Charnes et al. (1985) and Färe et al. (1994) applied panel data to DEA. The great advantage of panel data is that it provides a much more detailed evaluation of the relative performance of the production units under analysis. It is also possible to measure the changes in productivity of each producer and to decompose this productivity change into components.

[10] TFP accounts for the movements in the ratio that compares variations in output levels with respect to variations in input levels.

Nishimizu and Page (1982) and Aly and Grabowski (1988) adapted Farrell methodology in order to compute annual TFP indices. In a similar fashion, Prior (1990) explained the changes observed in the output of different Spanish regions as due to the increase in input usage and to the variations in the global productivity level in period 1981-1985. With this last indicator, the author refers to technical change and changes in technical efficiency, both perfectly differentiated in the study.

Our purpose is to provide further evidence concerning the determinants of the output growth allowing for a dynamic evaluation of a firm's performance over time. As already mentioned in the introduction, we decompose the output growth rate into three components: technical efficiency change, technical change and input changes. We distinguish also between the two main alternatives of measuring technical change: a) at the end of the period, with final year data (t+1) and, b) at the beginning of the period, with initial year data (t). It is also possible a third alternative usually applied in the decomposition of the Malmquist indices (Färe et al., 1994): c) take the average of the initial and final year results. For this last case, we give the theoretical framework but do not report the empirical results. Finally, from the input changes, we identify the scale effects component.

2.3.1. The Distance Function

Assume that we have ($j=1,...,k$) observations for the (m) outputs (y) produced with (n) inputs. Assume further on that we know the matrix of the observed outputs Y (dimensions kxm) and the matrix X (kxn) of the inputs. We can define in this way a vector of inputs (x_j) which participates into the production of the output vector (y_j) and only need to know the technology according to which the transformation process of the inputs into the outputs takes place. Since so much technical efficiency measurement is oriented toward output augmentation, the production technology will be represented with an output set. Shephard (1970) has proven that a linear technology verifying all the regularity, monotonicity, convexity and variable returns to scale properties can be defined as follows:

$$F(x) = \{y : (x, y)\ is\ \ feasible\} \tag{1}$$

and for every $x \in R_+^n$ has isoquant

$$Isoq\ F(x) = \{y : y \in F(x), zy \notin F(x), z \in (1,+\infty)\} \tag{2}$$

where z is the intensity vector, and $F(x_j)$ is the set of factors necessary to produce, at least, the *output* vector y_j. The *efficient* subset corresponding to (2) is

$$Eff\ \ F(x) = \{y : y \in F(x), y^* \notin F(x), y^* \geq y\} \tag{3}$$

with the property that $Eff\ \ P(x) \subseteq Isoq\ F(x)$. We move this way towards more reduced frontiers (from isoquant to the efficient frontier). Shepard's (1970) output distance function is defined as:

$$D_o(x, y) = \min\{e : (y / e) \in F(x)\} \tag{4}$$

where e is the value of the output distance function and gives the ratio of actual output to maximum potential output. The distance function takes a maximum value of unity for units operating on the frontier, and a value less than unity for units operating inside the frontier. In this last case, the distance function indicates the distance to the frontier for the output y. The efficient output level would be given by weighting the inputs' intensity with the one corresponding to the efficient frontier.

The Debreu-Farrell[11] output-oriented measure of technical efficiency becomes

$$DF_o(x, y) = \max\{f : fy \in F(x)\} \tag{5}$$

[11] For more details on the mathematical programming formulations and the algorithms used, the reader is referred to chapters 1 and 3 in Fried, Lovell, and Schmidt (1993), and Färe, Grosskopf, and Lovell (1994).

where *f* is the reciprocal of the distance function *e*, and gives the proportional expansion of output given the observed level of input usage. $f \geq 1$ and it follows from (4) that

$$DF_o(x, y) = \frac{1}{D_o(x, y)} \tag{6}$$

To estimate the output distance function defined by (4), we employ a non-parametric linear programming technique (DEA models). This technique serves to define the best practice frontier technology from all the data, without imposing any particular functional form. The value of the output distance function (*e*) serves as the measure of technical efficiency, for each unit (*j*) relative to the best practice frontier.

The linear programming problem used to calculate the best practice frontier for the output-oriented distance function (e_j), known as DEA relative to a VRS technology is the following:

$$\begin{aligned} &Min\ \mathrm{e}^t_{j,t} \\ s.t.:\ &z \cdot Y^t \geq y^t_j / e^t_{j,t} \\ &z \cdot X^t \leq x^t_{j,t} \\ &\vec{1} \cdot z = 1 \end{aligned} \tag{7}$$

where X and Y are the input and output matrices at moment t, already mentioned above.

Note that $\vec{1} \cdot z = 1$ corresponds to the DEA-BCC[12] problem (VRS), while an unrestricted sum leads to the DEA-CCR[13] problem or the constant returns to scale case (CRS). The computation of the radial efficiency measure involves solving one linear program for each observation j.

[12] Proposed by Banker, Charnes and Cooper (1984).
[13] Proposed by Charnes, Cooper and Rhodes (1978).

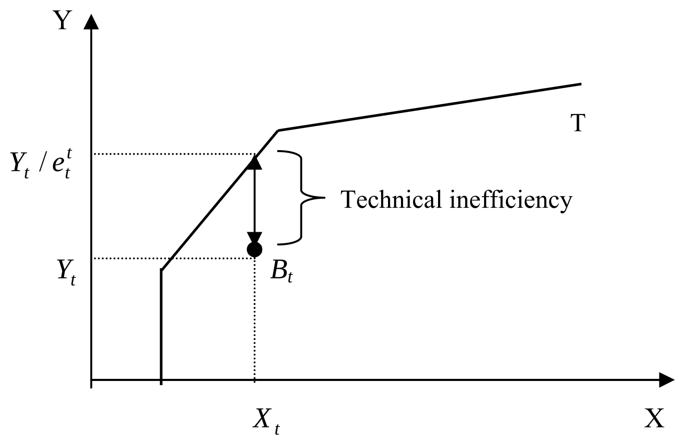


Figure 2.a. Technical Inefficiency with Variable Returns to Scale Technology

In Fig. 2.a. we can see the inefficiency level of unit B_t as being given by the vertical distance between the best practice frontier technology and the output level of the observed unit. For the constant returns to scale (CRS) case shown in Fig. 2.b., the vertical distance reveals the inefficiency with respect to the best practice frontier. To compute the best practice frontier for the CRS case we only need to drop out the last restriction ($\vec{1} \cdot z = 1$) in program (7) above.

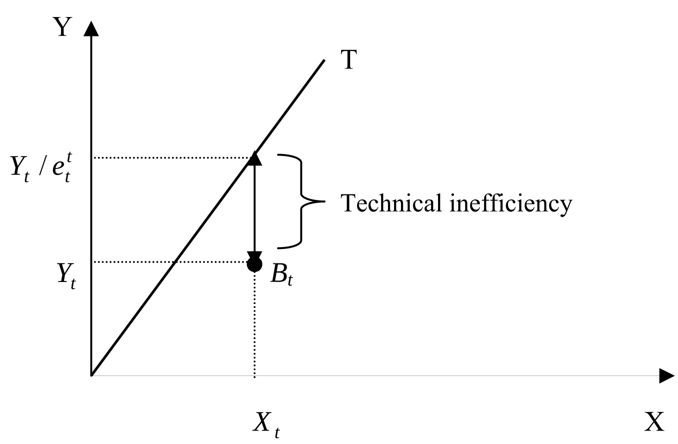


Figure 2.b. Technical Inefficiency with Constant Returns to Scale Technology

2.3.2. Components of Productivity Change: Technical Change, Technical Efficiency Change and Increments in Input Usage

Lets consider Y_t as being the output level at moment t, and Y_{t+1} the output corresponding to moment t+1 respectively. In general for the one-output case, the growth rate of output ($\dot{Y}$) for a given observation unit j will be given by the following relation:

$$\dot{Y} = \frac{Y_{j,t+1} - Y_{j,t}}{Y_{j,t}} \tag{8}$$

As already mentioned in the introduction, three main explanatory factors could be distinguished for the output growth rate given above:

$$\dot{Y} = \underbrace{\dot{CTE} + \dot{TC}}_{TFP} + \dot{I} \tag{9}$$

$$\text{and } \dot{I}_{VRS} = \dot{I}_{CRS} + SE \tag{9.1}$$

where:

$\dot{CTE}$: Growth due to changes in technical efficiency (movements towards the production frontier, the so-called catching up effect);

$\dot{TC}$: Growth due to technical changes (shifts in the production frontier);

$\dot{I}$: Growth due to an increment in input usage (movements along the same production frontier);

TFP: Total Factor Productivity;

SE: Scale Effects.

It is worthwhile to mention that expression (9) does not hold any longer if multiply terms instead of adding them. We now systematically discuss each of these three output growth components.

$\dot{CTE}$

The use of knowledge gained through imitation is usually assimilated with the catching up process. It is generally accepted that all countries have some ability to imitate i.e. the technology of the leader country. The literature on diffusion usually assumes that the diffusion of the internationally available knowledge takes place such that countries with a low level of efficiency are the ones that increase their productivity growth rates the most. Many empirical studies like i.e., Abramovitz (1986), Dollar and Wolff (1988), Dowrick and Nguyen (1989), etc. have been carried out on this issue. In this analysis, the changes in technical efficiency in relative terms ($\dot{CTE}$) could be taken as proxies for the catching up process.

An observation unit, firm in our case, that reduces the inefficiency is located at time t+1 closer to the frontier than it was at time t. This situation would be reflected by a positive technical efficiency variation index. In other words, this index shows us what is the increment in output's level realized by a firm that has managed to approach the potential output levels marked by the best practice frontier. For the already *efficient* units (frontier units) this index is zero ($\dot{CTE} = 0$), which can be interpreted as a status of efficiency level maintenance.

The indirect effects of other factors like i.e. technical change, that could induce a new production or organizational system, or the increment of the input usage are not considered. This index is sensitive to any improvement in the performance of the technology in use caused i.e. by personnel's skills and formation, and a better organization of the activity.

$\dot{TC}$

The second index explains which part of the variation observed in the output growth rate is due to a technical change. The intuition behind is that any innovation and improvement affecting the technology in use, tend to influence a firm's own frontier by the time. As a consequence, this shifts the upper bound of the production possibilities frontier known at a given time period upwards. It is important to point out that we measure the technical change, at the frontier. That is, the firms which are shifting the frontier technology are efficient (perform on the frontier).

Among the explanatory factors for a positive technical change there are the organisational changes realized by the efficient firms, R&D activities, or the spill-over effects of R&D. There is a large literature on R&D and productivity growth relationship. Griliches (1979) pointed out very well the problems related to the measurement of R&D contribution to the productivity growth in a production function framework. Schankerman (1981) refers to the analysis of R&D as a separate factor and the double-counting problem. Verspagen (1995) i.e., show that the R&D and productivity relationship depends to a large extent on the functional form chosen. Many of the problems raised in these studies prove at the same time that the interpretation of the results when R&D involved has to be taken with care.

Griliches (1979) i.e., refers to the problems related to the measurement of the so-called knowledge-stock, research and development capital, or the many forms spill-overs might take. The author distinguishes between R&D activities and R&D spill-overs. The first concept is related to the amount of technology created/*innovated* within a firm/sector as opposed to *imitation*. An innovation it is expected to shift upwards the best practice frontier of the firm/sector and to increase the rate of technical progress. At the same time would create inefficiency for the countries not able to manage this change. The R&D spill-over is a consequence of the very nature of technical change. There are positive externalities of knowledge creation and it is difficult to control others from free-riding. There are many forms of spill-overs: between business sectors in the economy, between (the same sectors in) different countries as well as i.e., between universities and business firms engaged in R&D activities. Spill-over effects should affect productivity in the same way as R&D activities. Given that we work with sectors from countries in transition and advanced market economies, it is interesting to point out the findings of Cohen and Levinthal (1989). The authors showed that for the R&D spill-overs are very important some of the characteristics of the receiving party. In other words, highly intensive R&D firms are at the same time better able to assimilate spill-overs. Educational quality of the labour force, or the characteristics of the national innovation system could accelerate/delay the assimilation of spill-overs.

A negative rate for the technical change (perfectly feasible as there are no restrictions imposed) would correspond to a situation of "technological amnesia", provoked i.e. by the incapacity to maintain the appropriate level of human capital formation, a deterioration of the organizational system's efficacy or, due to the impossibility to maintain the same capacity utilization degree.

$\underline{\dot{I}}$

This last index reflects that part of the variation in output explained by a variation in the level of inputs. For its evaluation are considered frontier values that include factors unaccounted for by changes in technical efficiency and technical change.

Next, we give a formal definition of the three indexes introduced above. As mentioned in the introduction, a problem not treated till now refers to the fact that technical change can be measured in three different manners (recall Figure 1):

a. With final year data $(Y_{j,t+1})$;

b. With initial year data $(Y_{j,t})$;

c. Taking the average of the final and initial year results.

A. Evaluation of the Output's Growth Rate Due to Technical Change with Final Year Data, $(Y_{j,t+1})$.

If Y - output level
j - the unit under analysis
e - output distance function
t - initial year
t+1 - final year

We introduce the following notational conventions to distinguish the different distance functions: the superscripts refer to the period used to construct the frontier and the subscripts refer to the period that is being evaluated.

Then, the growth in output due to changes in technical efficiency $\dot{CTE}$ is given by the following relation:

$$\frac{(Y_{j,t} / e^{t}_{j,t} - Y_{j,t}) - (Y_{j,t+1} / e^{t+1}_{j,t+1} - Y_{j,t+1})}{Y_{j,t}} \tag{10}$$

If refer to Figure 3 below, expression (10) quantifies $\dot{CTE}$ as the difference between the distances to the frontier at moment *t* and *t+1* for the unit B, (1) and (-1) in the figure. At moment t, the reference frontier technology is T and, at t+1 the reference frontier is T+1. The expression $(Y_{j,t} / e^{t}_{j,t} - Y_{j,t})$ i.e., is the difference between the *potential output* at moment t calculated relative to the frontier technology of moment t and, the *observed output* at moment *t*. That is, the catching up to the frontier at moment *t*. In a similar fashion, the second expression in the denominator represents the catching up to the frontier at *t+1*.

Furthermore, the growth in output due to technical change $(\dot{TC})$ is defined as:

$$\frac{Y_{j,t+1} / e^{t+1}_{j,t+1} - Y_{j,t+1} / e^{t}_{j,t+1}}{Y_{j,t}} \qquad (11)$$

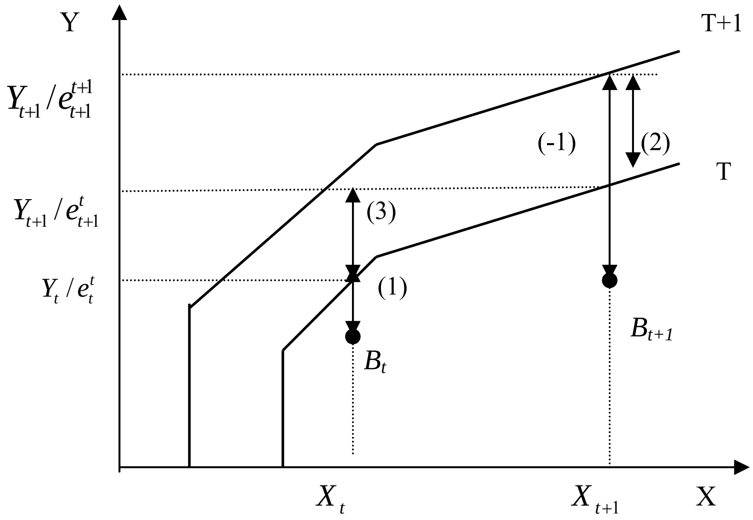
The technical change quantifies the shift in the frontier from T to T+1, and it is measured *at the frontier* and, at the end of the period. In Figure 3, it is given by (2). In expression (11) technical change is given by the difference between the potential output at moment *t+1* relative to the frontier technology at *t+1* and, the potential output at moment *t+1* if the frontier technology of moment *t* were available.

Finally, the growth in output due to an increment in input usage $\dot{I}$ is:

$$\frac{Y_{j,t+1} / e^{t}_{j,t+1} - Y_{j,t} / e^{t}_{j,t}}{Y_{j,t}} \qquad (12)$$

It is important to notice that the way we measure technical change (final / initial year) has no influence, as will see in the next pages, on the measurement of the catching up effect. The situation is not the same for the input changes. The fact that technical change is taken at the end of the period implies that when analysing unit B we will move from *t* to *t+1* along the frontier T. In other words, as shown in expression (12) input changes are measured at the frontier, the potential output both at moment *t* and *t+1* being calculated relative to the frontier at moment *t*. In Figure 3, (3).

The graphical representation corresponding to formulas (10)-(12), for the single-input, single-output case can be seen in Figure 3 presented below.



$(1):\dot{CTE}\quad(2):\dot{TC}\quad(3):\dot{I}$

Figure 3. Decomposition of the Output Growth Rate due to Technical Change with Final Year Data

B. Evaluation of the Output's Growth Rate Due to Technical Change, with Initial Year Data, $(Y_{j,t})$.

With the same notation as in the previous section the three factors are given now by the following expressions:

The growth in output due to changes in technical efficiency $(\dot{CTE})$ is given by an expression identical with the one defined by relation (10) above. As already mentioned before, the measurement of technical change has no influence on the technical efficiency change. If compare Figures 3 and 4, the distances (1) and (-1) are the same.

$$\frac{(Y_{j,t} / e^{t}_{j,t} - Y_{j,t}) \text{ - } (Y_{j,t+1} / e^{t+1}_{j,t+1} - Y_{j,t+1})}{Y_{j,t}} \qquad (13) = (10)$$

Next, the growth in output due to technical change $(\dot{TC})$ is given by:

$$\frac{Y_{j,t} / e^{t+1}_{j,t} - Y_{j,t} / e^{t}_{j,t}}{Y_{j,t}} \qquad (14)$$

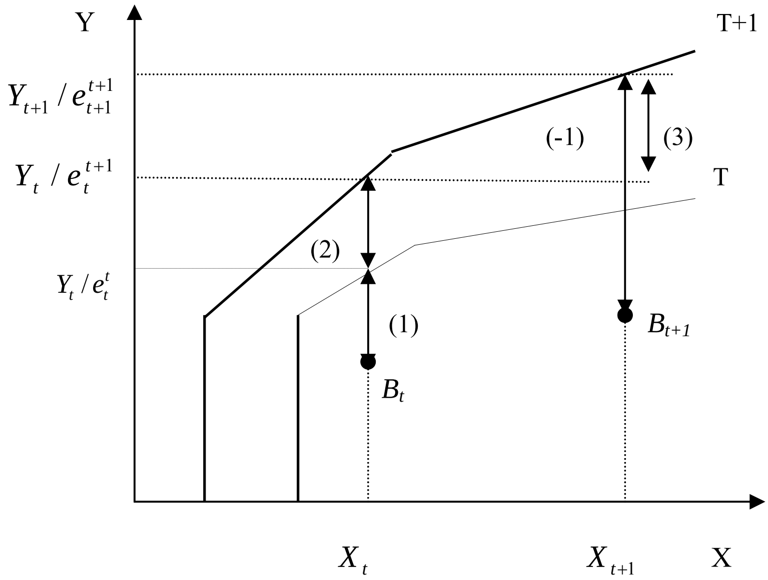
Now, technical change is measured at the frontier but at the beginning of the period, at moment *t*. Expression (14) gives the difference between the potential output at moment *t* if the frontier technology at moment *t+1* were available and, the potential output at moment *t* relative to the corresponding frontier technology at moment *t*. See (2) in Figure 4.

Finally, the growth in output due to an increment in input usage $(\dot{I})$ is:

$$\frac{Y_{j,t+1} / e^{t+1}_{j,t+1} - Y_{j,t} / e^{t+1}_{j,t}}{Y_{j,t}} \qquad (15)$$

Again, the measurement of technical change at the beginning of the period will condition the measurement of the variation in inputs. In Figure 4, it will be given by the movement along the frontier technology T+1. In expression (15), the input changes are given by the difference between potential output at moment *t+1* and *t*, in both cases calculated relative to the frontier technology at moment *t+1*. In Figure 4, is given by (3).

In Figure 4 hereafter, we present a graphical representation of this second decomposition approach analytically expressed in formulas (13)-(15).



$(1):\dot{CTE}\quad(2):\dot{TC}\quad(3):\dot{I}$

Figure 4. Decomposition of the Output Growth Rate due to Technical Change with Initial Year Data

C. Evaluation of Growth in Output Averaging Initial and Final Year Results

Operating with the decompositions presented in the previous two subsections we can obtain a third one. It consists of taking the average of the results of the two former approaches. This last decomposition goes in line with the applications based on Malmquist indexes which usually work with average results. The three components of the output growth rate are given by the following expressions:

The growth in output due to changes in technical efficiency ($\dot{CTE}$) undergoes no changes with respect to the two previous decompositions because is the arithmetic average of the expressions defined by relations (10) and (13) that are identical. In Figure 5, it corresponds to (1) and (-1).

$$\frac{(Y_{j,t} / e_{j,t}^{t} - Y_{j,t}) \text{ - } (Y_{j,t+1} / e_{j,t+1}^{t+1} - Y_{j,t+1})}{Y_{j,t}} \qquad (16)$$

The growth due to technical change $(\dot{TC})$ is given by the arithmetic average of the components defined by relations (11) and (14):

$$\frac{(1/2)(Y_{j,t+1} / e_{j,t+1}^{t+1} - Y_{j,t+1} / e_{j,t+1}^{t}) + (1/2)(Y_{j,t} / e_{j,t}^{t+1} - Y_{j,t} / e_{j,t}^{t})}{Y_{j,t}} \qquad (17)$$

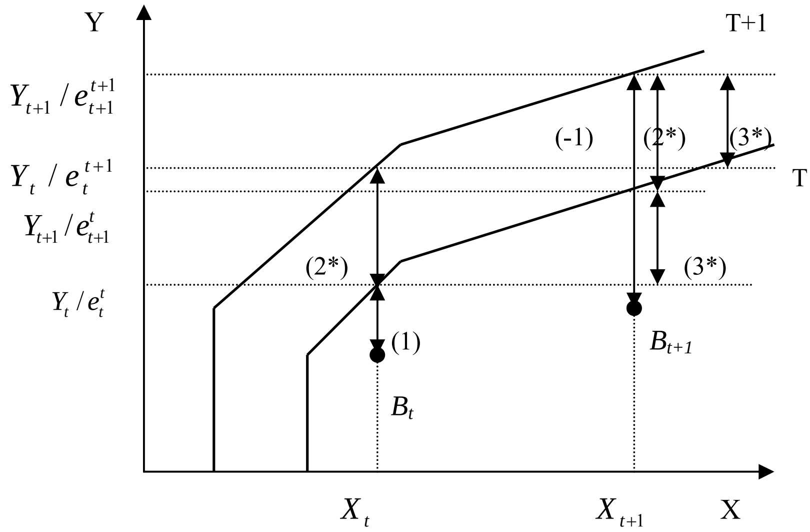
In this case we do not measure technical change neither at the beginning of the period (t) nor at the end ($t+1$) but rather take the average of the two measures. In Figure 5, see (2*).

Finally, the growth due to an increment in input usage $(\dot{I})$ is calculated averaging relations (12) and (15). In Figure 5, this variation is given by (3*).

$$\frac{(1/2)(Y_{j,t+1} / e_{j,t+1}^{t} - Y_{j,t} / e_{j,t}^{t}) + (1/2)(Y_{j,t+1} / e_{j,t+1}^{t+1} - Y_{j,t} / e_{j,t}^{t+1})}{Y_{j,t}} \qquad (18)$$

Again, we take the average of the two variations calculated before, along the frontier technology at moment t and $t+1$ respectively.

The graphical representation for the formulas (16)-(18) is presented in Figure 5.



$(1):\dot{CTE}\quad(2^*):\dot{TC}\quad(3^*):\dot{I}\quad$ * - averaged results

Figure 5. Decomposition of the Output Growth Rate due to Technical Change when Averaging Final and Initial Year Results

2.3.3. The Quantification of Distance Functions

To obtain the coefficients of the distance function (e_j) introduced above, we follow the approach of Nishimizu and Page (1982) adapted to the non-parametric framework by Färe, Groskopf, Lindgren and Roos (1994). There are two distance functions, in particular, that we need in order to perform the decompositions presented above.

The first one is necessary when considering the performance of the observed units at moment *t+1* with respect to the frontier technology of moment *t*. The linear programming problem which gives this distance function for a unit *j*, $(e_{j,t+1}^{t})$, is the following:

$$
\begin{aligned}
& Min\, e^{t}_{j,t+1} \\
s.t.: \quad & z \cdot Y^{t} \geq y_{j,t+1} / e^{t}_{j,t+1} \\
& z \cdot X^{t} \leq x_{j,t+1} \\
& \vec{1} \cdot z = 1 \qquad\qquad j = 1,\dots,k
\end{aligned}
\qquad (19)
$$

where Y^{t} and X^{t} are the output and input matrices at moment t; $Y_{j,t+1}$ is the output vector of firm *j* at moment *t+1*; $x_{j,t+1}$ is the input vector of firm *j* at moment *t+1* and *k* represents the total number of the firms in a given sector. Graphically, the distance $e^{t}_{j,t+1}$ function calculated by expression (19) can be seen in Figure 3 above.

In the same fashion, for the second distance function $e^{t+1}_{j,t}$ necessary to evaluate the observed units at moment *t* with respect to the frontier technology at moment *t+1*, the linear programming model is:

$$
\begin{aligned}
& Min\, e^{t+1}_{j,t} \\
s.t.: \quad & z \cdot Y^{t+1} \geq y_{j,t} / e^{t+1}_{j,t} \\
& z \cdot X^{t+1} \leq x_{j,t} \\
& \vec{1} \cdot z = 1 \qquad\qquad j = 1,\dots,k
\end{aligned}
\qquad (20)
$$

where Y^{t+1} and X^{t+1} stand for the matrices of outputs and inputs at moment *t+1*; $y_{j,t}$ is the output vector of unit *j* at moment *t*; $x_{j,t}$ is the input vector of unit *j* at moment *t* and *k* is the total number of the units (firms) in the sector. The graphical illustration is given in Figure 4.

2.4. Variables Definition and Empirical Results

For each industry sector over all countries, we construct a best-practice frontier from the data in the sector and compare each firm in that sector to that best practice frontier. The frontier is defined such that gives the maximum feasible output given the set of inputs, that is output orientation. We perform the estimations both for CRS and VRS settings. The results we present correspond to the time period 1995-1998.

The literature on productivity and efficiency analysis based on accounting data is very large. Nevertheless, there is no clear-cut point of view with respect to the most appropriate variables to be used in the analysis. On the contrary, the great dispersion observed in the definition of the variables is more likely to be justified by the limitations imposed by the data availability rather than a theoretical model. Prior (2002) gives a very complete survey of the most used accounting variables in the analysis of frontier efficiency. For the output variable i.e., authors like Worthington (1998), Piesse and Thirtle (2000), Hill and Kalirajan (1993) or, Huang and Liu (1994) work with the operating revenue / turnover. Zhu (2000) define multiple outputs e.g., return on investments, return on equity and operating profits. Others like Bowlin (1999) work with sales, operating cash-flow and net profits. Concerning the input dimension, the variation observed is also very great: material expenses and investments within the period (Bowlin,1999); cost with the employees, financial expenses and number of employees (Hill and Kalirajan, 1993); or material expenses and total assets in the case of Piesse and Thirtie (2000) and, the examples could continue.

We specify one output variable and three input variables for each industry sector. Our measure of output is the firm’s turnover. Fixed assets represent our proxy for the firm’s capital stock and material expenses stand for the second input variable. Employment is our third input and is proxied by the number of employees. An alternative definition for the labour input could have been working hours. When differ from one firm/country to another working hours could stand as a possible explanation for the differences observed in efficiency among firms in a group.

In our case, as we are evaluating firms from different countries and sectors, it is crucial the homogeneity of the information. All financial variables are expressed in 1995 constant prices (thousand dollars). A detailed description of data preparation and the Producer Price Indices (PPIs) used for correction is given in chapter 1.

In Appendix 2.1 we report descriptive statistics of the efficiency scores calculated with a CRS and VRS frontier technology, and output orientation. For each sector and for both decompositions – with initial and final year data - we give the units with positive (and negative) output growth rates and the corresponding components: technical efficiency change, technical change and growth in inputs usage.

We make this separation (positive and negative) because we do not present results at firm level. We present instead average values calculated separately for the sub-samples of firms that exhibited positive and negative output growth rates. From a mathematical point of view we consider that taking the average of positive and negative values all together makes it difficult to control for compensatory effects and, the final results would be biased. We apply the same rule for the standard deviation and give estimates for the (+) and (-) output growth rates sub-samples. In Table 1 we give estimates - for sector 172 (Textile Weaving) in a CRS setting.

Table 1: Sector 172 – Textile Weaving
Output growth decomposition with initial year (1995) data. CRS.

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs (+)	56			
DMUs (-)	111			
Infeasible Results	1			
Global Mean (+)	0.2317	0.0986	-0.0237	0.1568
Global Mean (-)	-0.4939	-0.2631	-0.0158	-0.2150
Standard Dev.(+)	0.3079	0.1992	0.0098	0.2153
Standard Dev.(-)	0.3907	0.2200	0.0355	0.1586
Max. Value	1.4195	1.0086	0.0477	1.2007
Min. Value	-0.9861	-0.6612	-0.2304	-0.6481
Skewness	0.2721	0.3799	-2.4720	1.0180
Kurtosis	0.1491	1.3041	9.6932	3.0381

Output growth decomposition with final year (1998) data. CRS.

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs(+)	56			
DMUs(-)	111			
Infeasible Results	1			
Global Mean (+)	0.2317	0.0986	-0.0640	0.1971
Global Mean (-)	-0.4939	-0.2631	-0.0096	-0.2212
Standard Dev.(+)	0.3079	0.1992	0.0105	0.3333
Standard Dev. (-)	0.3907	0.2200	0.1145	0.1642
Max. Value	1.4195	1.0086	0.0574	2.0650
Min. Value	-0.9861	-0.6612	-0.8283	-0.6627
Skewness	0.2721	0.3799	-6.3612	2.3252
Kurtosis	0.1491	1.3041	46.5991	12.2006

First of all, as explained in section 2.3.2., the *technical efficiency* index does not change when switching from the decomposition with final years data to the one with initial year data. This can be seen both from Table 1 and Tables in Appendix 2. Of course, the decomposition will be different when change from CRS to VRS framework.

A significant aspect to be mentioned is the presence of several infeasible results. It is not the case of all sectors but, the number is likely to increase when move from CRS to VRS frontier technology. When reporting the results with final and initial year data, we adjusted for the same number of infeasible units to make sure that the technical efficiency change effect does not vary. Otherwise, the interpretation of the results would not be the correct one. Where infeasibilities are present, the number is mentioned in the corresponding tables.

The increase in the number of infeasible units when moving from CRS to VRS technologies is due to the fact that the VRS technology is more restrictive. According to Wilson (1995) the infeasibility problem occurs when an observation unit lies above the frontier supported by the other units in the sample. Moreover, the frontier cannot be reached neither contracting nor expanding inputs, holding output constant. In Figure 6 below we illustrate this situation for a single input (x) and single output (y) case. This problem could be avoided with the CRS frontier.

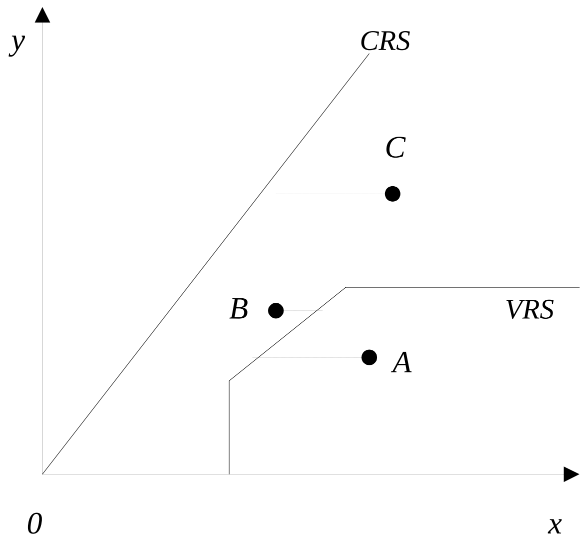


Figure 6. Infeasible Units

As it can be seen from the figure, unit C is infeasible for the VRS frontier but not for the CRS one. If this is the case it could be also that we are dealing with a problem of size as well. In principle as DEA works with ratios (relative terms) it controls for the differences between large and small units. Nevertheless, as already mentioned in Chapter 1, an alternative would be to take logs of the data before doing any estimation.

From the results we can see that for each sector on average, both for the initial and final year decomposition, the positive output growth rates are mainly explained by the catching up effect to the frontier, and the inputs usage factor. Both together dominate the technical change effect. For the firms with negative output growth rates, the main influence is again due to the technical efficiency change and the variation in inputs which in absolute terms dominate in magnitude the impact of technical change component.

Next, we group the three components of the output growth rate into Total Factor Productivity (TFP) and inputs change (see expression 9). The results are presented in Tables 2 and 3, for the CRS and VRS settings.

Table 2: TFP vs. variation in inputs' usage. CRS. (TFP = $\dot{CTE} + \dot{TC}$)

Group	Output Growth Rate	Initial Year Data (1995)		Final Year Data (1998)	
		TFP	Growth in Inputs	TFP	Growth in Inputs
172	0.2317	0.0749	0.1568	0.0346	0.1971
	-0.4939	-0.2789	-0.2150	-0.2727	-0.2212
175	0.3969	0.1937	0.2032	0.1517	0.2452
	-0.4322	-0.1969	-0.2353	-0.2566	-0.1755
211	0.2662	0.0813	0.1849	0.0616	0.2046
	-0.3262	-0.1239	-0.2023	-0.1312	-0.1950
241	0.2497	0.0525	0.1934	0.0539	0.1957
	-0.4593	-0.2820	-0.1773	-0.2931	-0.1662
251	0.2815	0.0954	0.1861	0.0588	0.2228
	-0.4516	-0.1898	-0.2618	-0.2120	-0.2397
252	0.2843	0.2010	0.0834	0.1678	0.1165
	-0.3708	-0.0908	-0.2800	-0.1832	-0.1876

As it can be seen from the table, for the positive output growth rates case, in five of the sectors (except for 252), both with final and initial year data the input factor dominates the TFP factor. This was somehow expected as it is known that in short-run firms are more likely to act upon inputs while the effects of a technological improvement (innovation and spill-overs) are stronger in the long-run.

Looking at the data in Appendix 2, we can see that when the output growth rate is positive, in all sectors, the input change factor is also positive. This observation allows us to conclude that firms, on average, are growing mainly because they increase the amount of input factors. On the one hand, if one looks at TFP's composition, again from the data we can see that $\dot{CTE}$ is always positive while $\dot{TC}$ exhibits both positive and negative signs. This means that in some cases the input effect is reinforced by the catch up effect and the shifts in the frontier, in other cases, both $\dot{CTE}$ and $\dot{TC}$ effects are diminishing the input effect, and in some cases it could happen that e.g., the catching up effect is adding up to the input effect while the frontier is shifting downwards or vice versa.

For the negative output growth rates case, the dominance of the TFP and input factors is a bit more distributed among sectors: with initial year's data in most of the sectors (except for 172 and 241), the effect of the variation in inputs' usage dominates the TFP factor. In the case of final year's data the input factor dominates in magnitude the TFP in half of the sectors (except for 172, 175 and 241). From the estimates in Appendix 2, we can see that the catching up and input effects are always negative while the technical change effect varies in sign. This observation simplifies the interpretation of the results. Firms are not growing, mainly because they loose efficiency and reduce inputs. Even if in some cases the frontier shifts upwards, this movement is not enough in order to compensate the previous effects.

The decomposition for the VRS setting is given in Table 3 below. The influence of the TFP and input factors in the growth rate of output is not substantially different from the case of CRS setting. With initial year's data, the positive growth rate is mainly explained by the increase in inputs usage in three of the sectors (172, 241, 251). With final year's data, the dominance of the input factor is very clear in all sectors but one (252). The negative output growth rate is overall explained by a negative sign for all factors. In very few cases the technical change effect exhibits a positive sign being at the same time very low in magnitude. Nevertheless, if we were to rank the importance of the TFP and input factors the situation is as follows: with initial year's data the inputs effect is greater in magnitude than the TFP factor in almost all sectors, except for 241. The influence is reversed for the final year's data case. Now, the TFP factor is more negative than the input factor in four of the sectors (except for 211 and 252).

Table 3: TFP vs. variation in inputs' usage. VRS. (TFP = $\dot{CTE} + \dot{TC}$)

Group	Output Growth Rate	Initial Year Data (1995)		Final Year Data (1998)	
		TFP	Growth in Inputs	TFP	Growth in Inputs
172	0.1768	0.0312	0.1456	-0.0806	0.2658
	-0.4871	-0.2504	-0.2367	-0.3034	-0.1837
175	0.2875	0.1492	0.1383	0.0315	0.2560
	-0.4257	-0.0129	-0.2636	-0.2217	-0.2040
211	0.2136	0.1372	0.0764	0.0246	0.1889
	-0.3209	-0.0920	-0.2288	-0.1344	-0.1864
241	0.2497	0.0474	0.2023	0.0179	0.2318
	-0.4573	-0.2507	-0.2066	-0.2700	-0.1873
251	0.2851	0.0960	0.1891	0.0365	0.2487
	-0.4506	-0.1577	-0.2929	-0.2615	-0.1891
252	0.2624	0.1612	0.1013	0.1349	0.1275
	-0.3640	-0.0589	-0.3051	-0.1817	-0.1823

Once arrived at this point, a small discussion on the evolution of the Gross Domestic Product (GDP) in Romania and Bulgaria, as transition countries in the sample, and the developed market economies, could be useful to understand the relatively high number of companies which exhibit a negative growth rate in output in period 1995 – 1998. For this purpose we present in the table below, evidence on the annual real growth of GDP in these countries over the period 1989 – 1998.

Table 4[14]: Annual Real Growth Rates of GDP - % changes from previous year

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bulgaria	0.5	-9.1	-11.7	-7.3	-1.5	1.8	2.1	-10.9	-6.9	3.5
Czech Republic	1.4	-1.2	-11.5	-3.3	0.6	3.2	6.3	3.9	1.0	-2.3
Hungary	0.7	-3.5	-11.9	-3.1	-0.6	2.9	1.5	1.3	4.6	4.9
Poland	0.2	-11.6	-7.0	2.6	3.8	5.2	7.0	6.1	6.9	5.0
Romania	-5.8	-5.6	-12.9	-8.8	1.5	3.9	7.1	3.9	-6.1	-5.4
France	3.9	2.4	0.8	1.1	-1.3	2.7	2.2	1.4	2.3	3.3
Netherlands	4.7	4.1	2.3	2.0	0.8	3.2	2.3	3.1	3.6	3.7
Spain	4.7	3.7	2.3	0.7	-1.2	2.3	2.7	2.4	3.5	4.0

As it can be noticed from the data, GDP fell in all transition countries in the early years of the period. The declines were particularly large in Bulgaria and Romania. Inflation, as measured by the Consumer Price Index (CPI), increased dramatically in all transition countries in the early part of the period.

This was mainly due to the fact that these countries had experienced artificially low rates of inflation under central planning. Inflation rates began to fall sharply after 1993 but even thereafter remained high compared to the EU countries. Table 5 exhibits statistical information on consumer prices:

[14] Source: "Transition at a Glance", Centre for Co-operation with Non-Members, CCNM/STD (2001)1, p.54

Table 5[15]: Consumer Prices - % changes from previous year

Country	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Bulgaria	6.0	26.0	333.0	79.4	72.9	96.0	62.1	123.0	1083.0	22.2
Czech Republic	1.0	26.0	56.8	11.1	20.8	10.0	9.1	8.8	8.5	10.6
Hungary	17.1	28.4	34.8	23.2	22.5	18.9	28.3	23.5	18.3	14.3
Poland	251.1	585.8	76.0	45.0	36.9	32.1	27.9	19.9	14.9	11.7
Romania	1.0	5.1	174.0	210.4	256.1	136.8	32.3	38.8	154.9	59.3
France	3.6	3.4	3.2	2.4	2.1	1.7	1.7	2.0	1.2	0.8
Netherlands	1.1	2.5	3.2	3.2	2.6	2.8	1.9	2.0	2.2	2.0
Spain	6.8	6.7	5.9	5.9	4.6	4.7	4.7	3.6	2.0	1.8

Given these results, we could try to see if the presence of returns to scale facilitates or, on the contrary, introduces difficulties in the inputs growth rate. As known, the impact in output level due to the growth in inputs is greater if increasing returns to scale prevails instead of decreasing returns to scale. We compute scale effects both with final and initial year data.

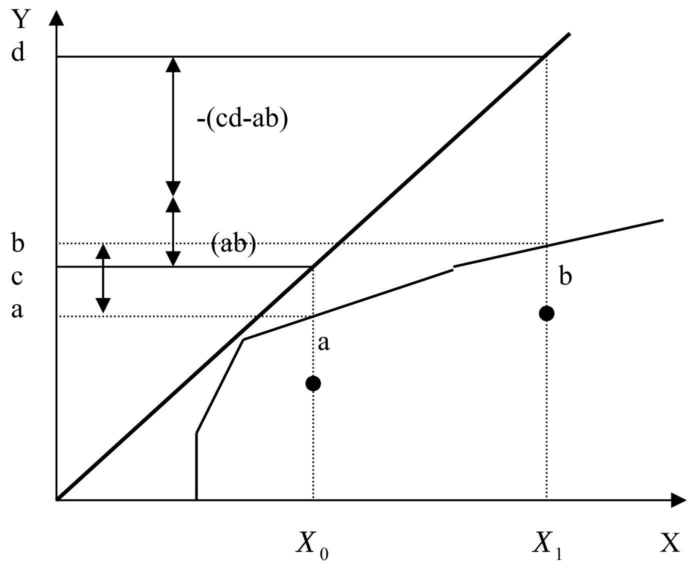
As explained in the introduction, we consider that the growth in output due to an increase in inputs usage – in a variable returns to scale setting - has two components: the potential growth in output corresponding to the CRS technology hence, increase in inputs usage with CRS and, the scale effect. In sections A and B we calculated input changes with final and initial year data, both with CRS and VRS technology. Hence, we can calculate scale effects with final and initial year data. In expression (21) we give the corresponding decompositions. The superscripts *t* and *t+1* stand for initial and final year data respectively.

$$\dot{I}^{\,t}_{VRS} = \dot{I}^{\,t}_{CRS} + SE^{t}$$
$$\dot{I}^{\,t+1}_{VRS} = \dot{I}^{\,t+1}_{CRS} + SE^{t+1} \qquad (21)$$

In Figure 7 we give the scale effect for the variation in inputs observed when move from *a* to *b*. The scale effect [-(cd-ab)] is defined as being the increase in inputs usage with VRS [ab] minus the increase in inputs usage with CRS [cd]. When there is growth in

[15] Source: “Transition at a Glance”, Centre for Co-operation with Non-Members, CCNM/STD (2001)1, p.68.

output - is to say positive output growth rates in our case – a negative scale effect indicates the presence of decreasing returns to scale.



(ab) = cd + (-(cd-ab))

Figure 7. Scale Effect Decomposition

In expression (22) we give an example of output growth rate decomposition with scale effects included, based on empirical results extracted from Appendices 2.1. and 2.2. We consider i.e., sector 241 and the case of the decomposition with final year data and VRS. From the table in Appendix 2.1.B p.77, we can see that the positive output growth rate (0.2497) is the sum of three explanatory factors. The last term can be further on decomposed in order to identify the scale effects. The values corresponding to variation in inputs with CRS and the scale effect respectively, are taken from the corresponding tables (Appendix 2.1 A., sector 241, output growth rate decomposition with final year and CRS, and Appendix 2.2., sector 241, scale effects with final year data).

$$0.2497 = \underbrace{0.0643}_{TechnicalEfficiencyChange} - \underbrace{0.0464}_{TechnicalChange} + \underbrace{\overbrace{0.1957 + 0.0361}^{InputChange(CRS)+ScaleEffect}}_{InputChange(VRS)=0.2318} \quad (22)$$

For the rest of the industries, the scale effects are presented in Appendix 2.2 at the end of the chapter. In some cases given that the number of infeasible observations varies from CRS to VRS frontier it could happen that the identity in the third term above will not be fully satisfied. In all sectors, except 211, there is a positive relationship between output growth rate and the scale effect, both are positive in sign. These findings go in the same line with the previous results: the input effect dominance is reinforced by the presence of increasing returns to scale.

2.5. Concluding Remarks

In the present analysis we introduce several elements of novelty. First, from the point of view of the methodology, the measurement of technical change with initial and final year data, and the scale effect decomposition via inputs usage, not applied up to now to a non-parametric setting (DEA). Second, the sample in itself, including data on Romanian and Bulgarian firms, contains two countries for which there is not that much work done on productivity analysis, with DEA in particular. Total Factor Productivity (TFP) is a standard measure of productivity, widely used in many empirical studies concerning the well-established market economies, but it has not been used to a large extent in transition economies, the main reason being the data availability[16].

We analyse firms' productivity and efficiency performance focusing on the growth in output and its main explanatory factors. We find that on average, the growth in output is mainly explained by the variation in inputs usage rather than improvements in technical efficiency or investment in technology. Moreover, the fact that in most of the cases we identified also non-constant returns to scale (positive scale effects), increases even more the impact of the input effect in explaining the growth of firms' turnover. We did not present here the decomposition of the output growth rate at the country level, but only for each sector across all countries. This decision was basically motivated by the estimates obtained at country level. In the case of the two transition economies e.g., the technical

[16] See Simeon Djankov (1997), "On the Determinants of Enterprise Adjustment: Evidence from Moldova", World Bank.

change effect is dominantly negative for these two countries in all sectors. This responds actually to our previous intuition that there are mainly the countries in the developed market economies who are shifting the technical frontier while the Eastern countries are trying to catch up or better said vary the input factor usage.

The dominance of a negative technical change effect, which is equivalent to technical *amnesia*, is explained by the fact that the firms in these countries have to handle an obsolete capital stock. This, combined with (R&D) labour force skills, could have a negative impact on the capability to assimilate eventual spill-overs as shown by Cohen and Levinthal (1989). Moreover, if one also considers the shrinking demand, these firms were obliged to reduce production, and maybe to transfer capital and layoff employees to other sectors.

The rapid restructuring which took place in many enterprises was imposed by the privatisation process rather than by the exigency of a competitive market system. This ex-ante privatisation restructuring process basically introduced changes in the ownership structure of the firms, i.e., most of the former state-owned enterprises were transformed into joint stock or limited liability companies. It is common knowledge by now that the new employee-owners priority was to maintain employment and avoid restructurings that could actually end up turning against themselves.

Summarising, with the sample of firms analysed here, our findings allow us to conclude that: on average in all sectors, the growth in output is mainly explained by the variation in inputs' usage rather than the TFP factor; the input effect is accompanied also by non-constant returns to scale; and the shifts in the frontier come from the block of countries in the developed market economies while the transition countries concentrate on inputs adjustment and the catch up to the frontier.

In the next chapter, we continue analysing the firms' performance but this time concentrate on the cost efficiency side rather than technical efficiency. We move this way from a less to a more restrictive non-parametric setting.

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Appendix 2.1.

A. Descriptive Statistics of the Efficiency Scores. Constant Returns to Scale Setting

Group 172 – Textile Weaving

Output growth rate decomposition with initial year (1995) data.

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs (+)	56			
DMUs (-)	111			
Infeasible Results	1			
Global Mean (+)	0.2317	0.0986	-0.0237	0.1568
Global Mean (-)	-0.4939	-0.2631	-0.0158	-0.2150
Standard Dev.(+)	0.3079	0.1992	0.0098	0.2153
Standard Dev.(-)	0.3907	0.2200	0.0355	0.1586
Max. Value	1.4195	1.0086	0.0477	1.2007
Min. Value	-0.9861	-0.6612	-0.2304	-0.6481
Skewness	0.2721	0.3799	-2.4720	1.0180
Kurtosis	0.1491	1.3041	9.6932	3.0381

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs(+)	56			
DMUs(-)	111			
Infeasible Results	1			
Global Mean (+)	0.2317	0.0986	-0.0640	0.1971
Global Mean (-)	-0.4939	-0.2631	-0.0096	-0.2212
Standard Dev.(+)	0.3079	0.1992	0.0105	0.3333
Standard Dev. (-)	0.3907	0.2200	0.1145	0.1642
Max. Value	1.4195	1.0086	0.0574	2.0650
Min. Value	-0.9861	-0.6612	-0.8283	-0.6627
Skewness	0.2721	0.3799	-6.3612	2.3252
Kurtosis	0.1491	1.3041	46.5991	12.2006

Group 175 – Manufacturing of Other Textiles

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	165			
DMUs(+)	67			
DMUs(-)	97			
Infeasible Results	1			
Global Mean (+)	0.3969	0.1277	0.0660	0.2032
Global Mean (-)	-0.4322	-0.2741	0.0772	-0.2353
Standard Dev.(+)	0.6786	0.2098	0.2755	0.4897
Standard Dev.(-)	0.3471	0.2596	0.0136	0.2701
Max. Value	4.8220	1.4905	2.0302	3.2711
Min. Value	-0.9767	-0.7037	-0.0698	-1.8228
Skewness	3.0448	0.2349	5.8589	2.7300
Kurtosis	20.5187	2.4226	41.6580	23.3368

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	165			
DMUs(+)	67			
DMUs(-)	97			
Infeasible Results	1			
Global Mean (+)	0.3969	0.1277	0.0240	0.2452
Global Mean (-)	-0.4322	-0.2741	0.0175	-0.1755
Standard Dev.(+)	0.6786	0.2098	0.0947	0.4920
Standard Dev. (-)	0.3471	0.2596	0.0258	0.1322
Max. Value	4.8220	1.4905	0.6810	3.4954
Min. Value	-0.9767	-0.7037	-0.1640	-0.7441
Skewness	3.0448	0.2349	4.2371	5.1830
Kurtosis	20.5187	2.4226	28.1988	41.3928

Group 211 – Manufacturing of Pulp, Paper and Paperboard

Output growth rate decomposition with initial year (1995) data

1995 – 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	149			
DMUs(+)	76			
DMUs(-)	73			
Global Mean (+)	0.2662	0.0648	0.0165	0.1849
Global Mean (-)	-0.3262	-0.0883	-0.0356	-0.2023
Standard Dev.(+)	0.3692	0.1028	0.0833	0.3572
Standard Dev.(-)	0.3138	0.1544	0.0702	0.1492
Max. Value	2.0213	0.4986	0.4637	2.0363
Min. Value	-0.9731	-0.5265	-0.3113	-0.6391
Skewness	0.8693	-0.6273	0.5949	2.4235
Kurtosis	4.8407	0.8337	3.7563	10.7078

Output growth rate decomposition with final year (1998) data

1995 – 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	149			
DMUs(+)	76			
DMUs(-)	73			
Global Mean (+)	0.2662	0.0648	-0.0032	0.2046
Global Mean (-)	-0.3262	-0.0883	-0.0429	-0.1950
Standard Dev.(+)	0.3692	0.1028	0.0795	0.2935
Standard Dev.(-)	0.3138	0.1544	0.0653	0.1710
Max. Value	2.0213	0.4986	0.4181	1.7288
Min. Value	-0.9731	-0.5265	-0.3898	-0.5783
Skewness	0.8693	-0.6273	0.3091	1.6805
Kurtosis	4.8407	0.8337	5.1431	6.9939

Group 241 – Manufacturing of Basic Chemicals

Output growth rate decomposition with initial year (1995) data

1995 – 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in inputs
Total DMUs	284			
DMUs(+)	126			
DMUs(-)	157			
Infeasible Results	1			
Global Mean (+)	0.2497	0.0546	-0.0021	0.1934
Global Mean (-)	-0.4593	-0.2899	0.0079	-0.1773
Standard Dev.(+)	0.3124	0.1015	0.0999	0.3198
Standard Dev.(-)	0.3646	0.2989	0.0418	0.1905
Max. Value	2.6442	0.5105	0.7901	2.8601
Min. Value	-0.9991	-0.8721	-0.2547	-1.2565
Skewness	0.3730	-0.8928	3.6770	2.5463
Kurtosis	2.8122	-0.4019	28.0473	25.3730

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	284			
DMUs(+)	126			
DMUs(-)	157			
Infeasible Results	1			
Global Mean (+)	0.2497	0.0583	-0.0044	0.1957
Global Mean (-)	-0.4593	-0.2899	-0.0032	-0.1662
Standard Dev.(+)	0.3124	0.1015	0.0390	0.3115
Standard Dev.(-)	0.3646	0.2989	0.0481	0.1307
Max. Value	2.6442	0.5105	0.2536	2.9567
Min. Value	-0.9991	-0.8721	-0.2895	-0.6827
Skewness	0.3730	-0.8928	-0.6615	3.8523
Kurtosis	2.8122	-0.4019	6.5577	34.7450

Group 251 – Manufacturing of Rubber Products

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	139			
DMUs (+)	69			
DMUs (-)	70			
Global Mean (+)	0.2815	0.0639	0.0315	0.1861
Global Mean (-)	-0.4516	-0.2100	0.0202	-0.2618
Standard Dev. (+)	0.3243	0.0946	0.1257	0.2622
Standard Dev. (-)	0.3672	0.2094	0.2197	0.2211
Max. Value	1.6319	0.5508	0.9294	1.3163
Min. Value	-0.9834	-0.6170	-0.0929	-1.0791
Skewness	0.1450	-0.7805	6.3514	0.4704
Kurtosis	0.5537	0.0524	47.5427	1.9464

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	139			
DMUs(+)	69			
DMUs(-)	70			
Global Mean (+)	0.2815	0.0639	-0.0051	0.2228
Global Mean (-)	-0.4516	-0.2100	-0.0020	-0.2397
Standard Dev.(+)	0.3243	0.0946	0.0235	0.2714
Standard Dev.(-)	0.3672	0.2094	0.0321	0.1917
Max. Value	1.6319	0.5508	0.0997	1.4549
Min. Value	-0.9834	-0.6170	-0.1913	-0.8876
Skewness	0.1450	-0.7805	-0.9818	0.8330
Kurtosis	0.5537	0.0524	4.8534	2.7510

Group 252 – Manufacturing of Plastic Products

Output growth rate decomposition with initial year (1995) data

1995 – 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	474			
DMUs(+)	230			
DMUs(-)	241			
Infeasible Results	3			
Global Mean (+)	0.2843	0.1355	0.0655	0.0834
Global Mean (-)	-0.3708	-0.2082	0.1174	-0.2800
Standard Dev.(+)	0.3809	0.2065	0.1478	0.2710
Standard Dev.(-)	0.3428	0.2855	0.0158	0.2307
Max. Value	4.1190	1.4029	1.4617	2.5450
Min. Value	-0.9767	-0.8046	-0.0806	-2.0348
Skewness	1.2438	-0.2929	2.9644	0.7280
Kurtosis	11.0807	0.7782	18.4783	8.9508

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	474			
DMUs(+)	230			
DMUs(-)	241			
Infeasible Results	3			
Global Mean (+)	0.2843	0.1355	0.0323	0.1165
Global Mean (-)	-0.3708	-0.2082	0.0250	-0.1876
Standard Dev.(+)	0.3809	0.2065	0.0691	0.2686
Standard Dev.(-)	0.3428	0.2855	0.0546	0.1247
Max. Value	4.1190	1.4029	0.5312	2.3704
Min. Value	-0.9767	-0.8046	-0.6473	-0.5808
Skewness	1.2438	-0.2929	0.0805	2.2327
Kurtosis	11.0807	0.7782	15.7172	13.7502

Appendix 2.1.

B. Descriptive Statistics of the Efficiency Scores. Variable Returns to Scale Setting.

Group 172 – Textile Weaving

Output growth rate decomposition with initial year (1995) data.

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs(+)	53			
DMUs(-)	108			
Infeasible Results	7			
Global Mean (+)	0.1768	0.0228	0.0084	0.1456
Global Mean (-)	-0.4871	-0.2403	-0.0101	-0.2367
Standard Dev.(+)	0.2017	0.0871	0.0683	0.1921
Standard Dev.(-)	0.3691	0.2233	0.4295	0.1514
Max. Value	1.0558	0.4655	0.4964	1.0761
Min. Value	-0.9861	-0.6622	-0.1467	-0.6434
Skewness	-0.1542	-0.5165	2.7889	0.9429
Kurtosis	-0.8307	-0.8814	21.0516	2.4631

Output growth rate decomposition with final year (1998) data.

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	168			
DMUs(+)	53			
DMUs(-)	108			
Infeasible Results	7			
Global Mean (+)	0.1768	0.0228	-0.1034	0.2658
Global Mean (-)	-0.4871	-0.2403	-0.0631	-0.1837
Standard Dev.(+)	0.2017	0.0871	0.0249	0.5759
Standard Dev.(-)	0.3691	0.2233	0.4295	0.1514
Max. Value	1.0558	0.4655	0.1142	2.8850
Min. Value	-0.9861	-0.6622	-3.2691	-0.6604
Skewness	-0.1542	-0.5165	-7.0348	3.4386
Kurtosis	-0.8307	-0.8814	55.5114	16.5056

Group 175 – Manufacturing of Other Textiles

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	165			
DMUs(+)	63			
DMUs(-)	96			
Infeasible Results	6			
Global Mean (+)	0.2875	0.0918	0.0574	0.1383
Global Mean (-)	-0.4257	-0.2229	0.0608	-0.2636
Standard Dev.(+)	0.2782	0.1227	0.3276	0.2856
Standard Dev.(-)	0.3497	0.2424	0.0346	0.2947
Max. Value	1.4735	0.6466	2.3569	0.8638
Min. Value	-0.9767	-0.7012	-0.2207	-1.8474
Skewness	0.0481	-0.5905	5.6738	-1.2872
Kurtosis	0.0912	-0.3229	40.6360	5.7879

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	165			
DMUs(+)	63			
DMUs(-)	96			
Infeasible Results	6			
Global Mean (+)	0.2875	0.0918	-0.0603	0.2560
Global Mean (-)	-0.4257	-0.2229	0.0012	-0.2040
Standard Dev.(+)	0.2782	0.1227	0.0425	0.2955
Standard Dev.(-)	0.3497	0.2424	0.0847	0.1571
Max. Value	1.4735	0.6466	0.1700	1.5792
Min. Value	-0.9767	-0.7012	-0.4727	-0.7359
Skewness	0.0481	-0.5905	-1.7975	1.4318
Kurtosis	0.0912	-0.3229	6.7851	4.4655

Group 211 – Manufacturing of Pulp, Paper and Paperboard

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	149			
DMUs(+)	70			
DMUs(-)	72			
Infeasible Results	7			
Global Mean (+)	0.2136	0.0768	0.0604	0.0764
Global Mean (-)	-0.3209	-0.0720	-0.0200	-0.2288
Standard Dev.(+)	0.2754	0.0982	0.3948	0.2660
Standard Dev.(-)	0.3127	0.1610	0.0531	0.3049
Max. Value	2.0213	0.3770	2.6062	1.9850
Min. Value	-0.9731	-0.5228	-0.3502	-2.4110
Skewness	0.3082	-0.8611	7.4042	-0.7393
Kurtosis	5.1334	1.0638	68.6703	17.9315

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	149			
DMUs(+)	70			
DMUs(-)	72			
Infeasible Results	7			
Global Mean (+)	0.2136	0.0768	-0.0522	0.1889
Global Mean (-)	-0.3209	-0.0720	-0.0624	-0.1864
Standard Dev.(+)	0.2754	0.0982	0.0433	0.2739
Standard Dev.(-)	0.3127	0.1610	0.1165	0.1630
Max. Value	2.0213	0.3770	0.1516	1.9966
Min. Value	-0.9731	-0.5228	-0.8353	-0.6375
Skewness	0.3082	-0.8611	-3.9247	1.9062
Kurtosis	5.1334	1.0638	21.8122	11.1706

Group 241 – Manufacturing of Basic Chemicals

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	284			
DMUs(+)	126			
DMUs(-)	154			
Infeasible Results	4			
Global Mean (+)	0.2497	0.0643	-0.0169	0.2023
Global Mean (-)	-0.4573	-0.2430	-0.0077	-0.2066
Standard Dev.(+)	0.3124	0.1076	0.0974	0.3022
Standard Dev.(-)	0.0000	0.2778	0.0500	0.1796
Max. Value	2.6442	0.5219	0.6624	2.7455
Min. Value	-0.9991	-0.8717	-0.3766	-0.8020
Skewness	0.3609	-0.9249	2.5872	2.3862
Kurtosis	2.8364	-0.0012	21.2516	19.2461

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	284			
DMUs(+)	126			
DMUs(-)	154			
Infeasible Results	4			
Global Mean (+)	0.2497	0.0643	-0.0464	0.2318
Global Mean (-)	-0.4573	-0.2430	-0.0270	-0.1873
Standard Dev.(+)	0.3124	0.1076	0.0150	0.3757
Standard Dev.(-)	0.0000	0.2778	0.1527	0.1593
Max. Value	2.6442	0.5219	0.1025	3.4077
Min. Value	-0.9991	-0.8717	-1.3462	-0.9159
Skewness	0.3609	-0.9249	-7.2877	3.5980
Kurtosis	2.8364	-0.0012	63.7575	29.2885

Group 251 – Manufacturing of Rubber Products

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	139			
DMUs(+)	65			
DMUs(-)	65			
Infeasible Results	9			
Global Mean (+)	0.2851	0.0339	0.0621	0.1891
Global Mean (-)	-0.4506	-0.2134	0.0557	-0.2929
Standard Dev.(+)	0.3284	0.1004	0.1876	0.2574
Standard Dev.(-)	0.3695	0.2061	0.0182	0.2734
Max. Value	1.6319	0.5823	1.1035	1.2630
Min. Value	-0.9834	-0.6076	-0.0679	-1.3418
Skewness	0.1535	-0.7302	4.6186	-0.0369
Kurtosis	0.5985	0.3702	22.7612	1.6934

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	139			
DMUs(+)	65			
DMUs(-)	65			
Infeasible Results	9			
Global Mean (+)	0.2851	0.0339	0.0026	0.2487
Global Mean (-)	-0.4506	-0.2134	-0.0481	-0.1891
Standard Dev.(+)	0.3284	0.1004	0.0412	0.3739
Standard Dev.(-)	0.3695	0.2061	0.4065	0.1821
Max. Value	1.6319	0.5823	0.1851	2.3149
Min. Value	-0.9834	-0.6076	-3.1372	-0.7857
Skewness	0.1535	-0.7302	-10.6576	2.0183
Kurtosis	0.5985	0.3702	118.6196	8.9915

Group 252 – Manufacturing of Plastic Products

Output growth rate decomposition with initial year (1995) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	474			
DMUs(+)	227			
DMUs(-)	238			
Infeasible Results	9			
Global Mean (+)	0.2624	0.0657	0.0955	0.1013
Global Mean (-)	-0.3640	-0.2021	0.1432	-0.3051
Standard Dev.(+)	0.2802	0.1729	0.1604	0.2275
Standard Dev.(-)	0.2054	0.1616	0.1273	0.1976
Max. Value	1.4202	1.0492	1.4617	1.1213
Min. Value	-0.9767	-0.8040	-0.0567	-2.0231
Skewness	-0.0780	-0.3960	3.5027	-0.1829
Kurtosis	0.7332	0.5559	20.2058	2.7085

Output growth rate decomposition with final year (1998) data

1995 - 1998	Output Growth Rate	Technical Efficiency Change	Technical Change	Growth in Inputs
Total DMUs	474			
DMUs(+)	227			
DMUs(-)	238			
Infeasible Results	9			
Global Mean (+)	0.2624	0.0657	0.0692	0.1275
Global Mean (-)	-0.3640	-0.2021	0.0204	-0.1823
Standard Dev.(+)	0.2802	0.1729	0.0756	0.3031
Standard Dev.(-)	0.2054	0.1616	0.3787	0.1329
Max. Value	1.4202	1.0492	0.5325	2.2371
Min. Value	-0.9767	-0.8040	-2.4910	-0.6469
Skewness	-0.0780	-0.3960	-9.8597	2.1256
Kurtosis	0.7332	0.5559	126.7891	10.0494

Appendix 2.2.

Scale Effects (SE)

Group 172 – Textile Weaving

1995 – 1998	Output Growth Rate	SE – initial year data (1995)	Output Growth Rate	SE – final year data (1998)
Total DMUs	168	168	168	168
DMUs (+)	53	(79)	53	(87)
DMUs (-)	108	(82)	108	(74)
Infeasible Results	7	7	7	7
Global Mean (+)	0.1768	0.0136	0.1768	0.0850
Global Mean (-)	-0.4871	-0.0265	-0.4871	0.0325
Standard Dev.(+)	0.2017	0.0728	0.2017	0.4686
Standard Dev.(-)	0.3691	0.0844	0.3691	0.0619
Max. Value	1.0558	0.5735	1.0558	3.2839
Min. Value	-0.9861	-0.6678	-0.9861	-0.3211
Skewness	-0.1542	-0.8116	-0.1542	7.0779
Kurtosis	-0.8307	29.9653	-0.8307	55.0810

Group 175 – Manufacturing of Other Textiles

1995 – 1998	Output Growth Rate	SE - initial year data (1995)	Output Growth Rate	SE – final year data (1998)
Total DMUs	165	165	165	165
DMUs (+)	63	(63)	67	(79)
DMUs (-)	96	(96)	96	(84)
Infeasible Results	6	(6)	2	(2)
Global Mean (+)	0.2875	0.0036	0.3969	0.0822
Global Mean (-)	-0.4257	-0.0304	-0.4295	-0.0363
Standard Dev.(+)	0.2782	0.0587	1.0000	0.1316
Standard Dev.(-)	0.3497	0.1024	0.3482	0.0916
Max. Value	1.4735	0.2774	4.8220	84.0000
Min. Value	-0.9767	-0.7464	-0.9767	-0.5440
Skewness	0.0481	-3.0063	3.0472	8.9772
Kurtosis	0.0912	20.5739	20.5496	79.6844

Group 211 – Manufacturing of Pulp, Paper and Paperboard

1995 – 1998	Output Growth Rate	SE - initial year data (1995)	Output Growth Rate	SE – final year data (1998)
Total DMUs	149	149	149	149
DMUs (+)	71	(71)	74	(71)
DMUs (-)	73	(73)	72	(75)
Infeasible Results	5	(5)	3	(3)
Global Mean (+)	0.2374	-0.0671	0.0743	-0.0084
Global Mean (-)	-0.3262	-0.0294	-0.1347	0.0237
Standard Dev.(+)	0.3394	0.0618	0.3191	0.1274
Standard Dev.(-)	0.0000	0.3394	0.3127	0.0723
Max. Value	2.0213	0.4364	2.0213	0.7330
Min. Value	-0.9731	-2.4355	-0.9731	-0.3591
Skewness	0.8219	-7.9686	0.5195	3.3145
Kurtosis	5.9028	78.6644	4.2803	24.3582

Group 241 – Manufacturing of Basic Chemicals

1995 – 1998	Output Growth Rate	SE - initial year's data (1995	Output Growth Rate	SE – final year's data (1998)
Total DMUs	284	284	284	284
DMUs (+)	127	(120)	126	(132)
DMUs (-)	156	(163)	154	(148)
Infeasible Results	1	(1)	4	(4)
Global Mean (+)	0.2556	-0.0155	0.2497	0.0361
Global Mean (-)	-0.4603	-0.0214	-0.4573	-0.0258
Standard Dev.(+)	0.3183	0.0369	0.3124	0.1646
Standard Dev.(-)	0.3656	0.0868	0.3667	0.0679
Max. Value	2.6442	0.2445	2.6442	1.4088
Min. Value	-0.9991	-0.6939	-0.9991	-0.3594
Skewness	0.3794	-3.8699	0.3602	5.6881
Kurtosis	2.6862	27.7774	2.8156	53.2295

Group 251 – Manufacturing of Rubber Products

1995 – 1998	Output Growth Rate	SE - initial year's data (1995)	Output Growth Rate	SE – final year's data (1998)
Total DMUs	139	139	139	139
DMUs (+)	65	(55)	69	(68)
DMUs (-)	67	(77)	67	(68)
Infeasible Results	7	(7)	3	(3)
Global Mean (+)	0.2851	-0.0206	0.2815	0.0186
Global Mean (-)	-0.4624	-0.0371	-0.4442	0.0410
Standard Dev.(+)	0.3284	0.0352	0.3243	0.3878
Standard Dev.(-)	0.4026	0.1787	0.3673	0.0259
Max. Value	1.6319	0.1705	1.6319	3.2025
Min. Value	-0.9834	-1.1077	-0.9834	-0.1283
Skewness	0.1646	-5.1652	0.1319	11.1434
Kurtosis	0.5004	31.1308	0.6291	127.7344

Group 252 – Manufacturing of Plastic Products

1995 – 1998	Output Growth Rate	SE - initial year's data (1995)	Output Growth Rate	SE – final year's data (1998)
Total DMUs	474	474	474	474
DMUs (+)	227	233	(230)	(237)
DMUs (-)	240	234	(238)	(231)
Infeasible Results	7	7	(6)	(6)
Global Mean (+)	0.2624	0.0244	0.2843	0.0180
Global Mean (-)	-0.3705	-0.0278	-0.3657	0.0018
Standard Dev.(+)	0.2802	0.0662	0.3809	0.2307
Standard Dev.(-)	0.3435	0.1054	0.3418	0.0612
Max. Value	1.4202	0.4251	4.1190	2.4966
Min. Value	-0.9767	-0.9787	-0.9767	-0.4513
Skewness	-0.0727	-3.8488	1.2603	10.9918
Kurtosis	0.6692	39.1689	11.3145	146.7490

Chapter 3

On the Measurement of Capacity Utilisation and Cost Efficiency: A Non-Parametric Approach at Firm Level[17]

3.1. Introduction

In the previous chapter we have assessed the performance of the firm analysing the main contributing factors in the growth of output. Hereafter, the purpose stays the same, appraise the firm's performance, but from the point of view of efficiency in costs. The concept of capacity utilisation (CU) has been largely analysed in the economic literature from various perspectives, both theoretically and empirically, and has been very often used to explain changes in macroeconomic indicators like inflation rate or labour productivity. Many alternative CU measures have also been defined, but due to interpretation problems there does not exist a consensus as to the most appropriate way of defining and measuring CU. In this chapter, we approach the notion of CU from the perspective offered by the economic theory of the firm, as a short-run concept depending on the level of fixed inputs of a firm.

In general, firms face difficulties in adjusting the fixed factors' endowments and this generates differences in the degree of capacity utilisation or in other words, inefficiency. Many times, the ability to adjust the fixed inputs – generating the so-called structural inefficiency - could be somehow slowed down by the presence of

[17] Preliminary versions of this chapter have been presented in the 24th Simposio de Analisis Ecónomico, IAE, Barcelona, Spain, December 1999; the EURO Working group DEAPM Seminar Day, Copenhagen, Denmark, October 1999; the 2nd Oviedo Workshop on Efficiency, Spain, May 2000 and in the CEMAPRE Conference, Lisbon, June 2000. A paper based on this chapter is forthcoming in *Pesquisa Operacional*, Brasil, 22(2), 2002.

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other factors like i.e.: adjustment costs, administrative regulations, external factors or measures of rationalisation, etc.

Our main purpose is to present a method of how to quantify cost inefficiency generated by the structural factors, in our case the impossibility in the short-run for the complete adjustment of the fixed (or quasi-fixed) inputs. This lack of adjustment, or better said the incapacity of firms to control for all fixed inputs' variations in the short-run, generates differences in the rate of capacity utilisation.

The research was inspired by a previous work done by Prior (2003) where the author applies a similar methodology to the analysis of a sample of Spanish saving banks. Here, we use for the empirical application a sample of Romanian firms of the chemical industry over the period 1996-1997, classified in three digits groups. We present for every group - in average terms - the degree of utilisation for the fixed inputs in the short-run (CU), and the coefficients of cost efficiency in the long-run, short-run, and structural efficiency.

This analysis goes in the same fashion with the previous chapter, being developed as well within the framework of non-parametric (linear programming) frontier evaluation known as Data Envelopment Analysis (DEA) in which a measure of capacity utilisation is determined from data on observed inputs and outputs. Many times the concept of capacity is closely related to the technological characteristics of the production process. For this reason, DEA has the great advantage that it doesn't require any *a priori* specification about a particular functional form and this ensures the sufficient flexibility to adapt to the specific characteristics of the observed unit.

More about the most used definitions of CU and about the implications of the notion of optimal level of output from the perspective of production functions' theory, in the next section. In sections 2 and 3 we explain the models, in section 4 we present the data, in section 5 the results, and in section 6 we conclude.

3.2. Brief Review of the Literature on Capacity Utilisation

One of the most used definitions of CU rate is as the ratio of actual output to the potential output. Concerning the potential output, there are several ways to define it. On the one hand, there is the engineering or technical approach according to which potential output represents the maximum amount of output that can be produced in the short-run with the existent stock of capital (see Nelson 1989, p. 273). A similar discussion can be found in Johansen (1968, see Färe, Grosskopf & Kokkelenberg, 1989, p.655), where the author defines the capacity as being: «... the maximum amount that can be produced per unit of time with existing plant and equipment, provided that the availability of variable factors of production is not restricted.»

Following this last definition, in one of his papers Färe (1984) describes the necessary and sufficient conditions for the existence of plant capacity as defined by Johansen. In a similar fashion, Färe, Grosskopf & Kokkelenberg (1989) developed measures of plant capacity, plant capacity utilisation and technical change in the short-run for multi-product firms, based on frontier models using non-parametric linear programming methods (DEA).

The economic approach, on the other hand, defines the potential output as being the optimum level of output from the economic point of view. This alternative considers capital as a quasi-fixed input, and allows for distinction between short- and long - run cost curves. In the long - run, capital can be adjusted in order to achieve optimal (cost-minimising, profit-maximising) level. In the short-run capital is fixed and only the variable inputs can be varied. The short-run equilibrium output, for a competitive firm, is then given by the equality between exogenous output price and the short-run marginal cost curve (SRMC), Y^*. The potential output would correspond to that level of output at which short-run average total cost (SRATC) is minimised – Y^{**}- (and equal to long-run average total cost, LRATC).

The definition of output as Y^{**} corresponds to the cost-minimisation problem while Y^* corresponds to profit-maximisation. As pointed out in Berndt & Morrison (1981), this difference can affect short-run equilibrium in the sense that it may or may not occur at the level of output were the SRATC reaches its minimum: $Y^* > Y^{**}$ or ($Y^* < Y^{**}$) when the output price is greater than (lower than) the minimum level of the SRATC. The authors address also the issue of how variations in input prices might affect the minimum point of the SRATC and hence Y^{**}.

This economic approach was first analysed by Cassels (1937) and latter on two more definitions have been introduced. The first was suggested by Klein (1960) and Friedman (1963) and more recently by Segerson and Squires (1990) who define the potential output as being the output level at which the long-run and short-run average total cost curves are tangent. The second approach supported by Cassels (1937) and Hickman (1964) takes as reference the output level at which the short-run average total cost curve reaches its minimum. The relationship between the two economic measures of CU depends upon the degree of scale economies for the unit that is being analysed. Berndt and Hesse (1986) advocate that under the assumption of prevailing constant returns to scale in the long-run, the tangency point between the long-run and short-run curves will coincide with the point where the long-run and short-run average total cost curves reach their minimum. Hence the two economic measures of CU would be equivalent. Nelson (1989, p.274), using data from a sample of US privately owned electric utilities reaches the conclusion that: « The choice of a particular measure of CU may be of little consequence if all of the measures are highly correlated, and if the correlation is constant over time and across firms. If this is not the case, however, the choice may influence the conclusions to be drawn from a study.»

3.3. Modelling Cost Efficiency in the Short and Long - Run

Any of the definitions of capacity given above is more or less valid depending on the specific technological characteristics of the production process in question. This is the reason why, whatever the method used to evaluate cost efficiency, this method should be sufficiently flexible in order to adjust without restrictions to the characteristics of the unit or firm analysed. Before developing the model it is worthwhile to mention that as we try to determine the cost efficiency level it is fundamental the distinction between fixed and variable inputs.

Model 1

The notation we shall introduce here will be valid for the rest of the paper. Let us assume we have *k* decision making units (DMUs) –firms in our case- to evaluate (*j=1,...,k).* The variables we need are the following: the input vector $x = (x_1,...,x_n) \in R_+^n$, the output vector $y = (y_1,...,y_m) \in R_+^m$ and the technology that describes the transformation of inputs into outputs as given below:

$$F(y) = \{ x : (y ,x) \ possible\} \quad (1)$$

We classify the inputs into fixed (x_f), the inputs which do not allow for adjustment in the short-run, but can be varied in the long-run, and variable (x_v), the inputs which are totally controlled by the firm in the short-run. The correspondent price vectors are: ω_v for the variable inputs, ω_f for the fixed inputs, and *P*, the output price vector. The typical optimisation problem faced by the firm is that of maximising variable profits (revenues minus variable costs) conditional on output price (*P*), prices of the variable inputs ω_v and fixed inputs, x_f. An alternative framework, which we follow in this paper, is to solve the dual optimisation problem: minimisation of variable costs conditional on *Y*, ω_v, and x_f. Under certain regularity conditions, for the production possibilities set in (1) it exists a short-run dual variable cost function which, will be given by:

$$VC(\omega_v, y, x_f) = \min_{x_v}\{\omega_v \cdot x_v /(x_v, x_f) \in F(y)\} \quad (2)$$

For the empirical application, we shall be working with three inputs: (1) material expenses, (2) labour and (3) physical capital. Inputs (1) and (2) are defined as variables in the short-run while input (3) is quasi-fixed. In the long-run all inputs can be varied. We do not have specific information about the prices of inputs for every firm. For this reason, in the short-run our vector ω_v, consists of: a unit vector, for the input (1) already in monetary terms, and wages for the second input. In the long-run, ω_v will include also as price for the capital input, the depreciation cost of capital (δ%). The price vector for the fixed input (capital in the short-run), ω_f, consists of a unit vector as capital is already expressed in monetary terms. If we sum-up the cost of fixed inputs to expression (2) above, we obtain the short-run total cost function (SRTC):

$$SRTC = VC(\omega_v, y, x_f) + \omega_f \cdot x_f \tag{3}$$

Relation (3) above represents in fact the tangency condition between the short-run and long- run total cost curves. If x_f^* represents the optimal value of fixed inputs, which minimises *SRTC*, then

$$\left(\frac{\partial SRTC}{\partial x_f}\right)_{x_f = x_f^*} = \left(\frac{\partial VC}{\partial x_f}\right)_{x_f = x_f^*} + \omega_f = 0 \tag{4}$$

at $x_f = x_f^*$. Equation (4) actually implies that, in long-run equilibrium, the reduction in variable costs from the last unit of fixed inputs just equals the price of fixed inputs. Solving equation (4) with respect to x_f and substituting the result into equation (3) yields the long - run total cost function (*LRTC*):

$$LRTC = LRTC\,(\omega_v, \omega_f; y) \tag{5}$$

Equation (5) would correspond to the dual of the production set if the firm were to minimise its total cost. In fact, *SRTC=LRTC* if and only if $x_f = x_f^*$. When different, *SRTC* is always larger than *LRTC*. Another way of putting it is that *SRTC* and *LRTC* are tangent at $x_f = x_f^*$. Resuming, SRTC is an accepted representation of the technology even if $x_f \neq x_f^*$ whereas LRTC is valid only when $x_f = x_f^*$. The outcomes of this process are first the *VC*, and second the optimal values for the fixed inputs x_f^*. All together represent in fact the long-run equilibrium for a given firm. Knowing the real and optimal values for inputs (*x*), *SRTC* and *LRTC*, we can measure the distance between the two levels of fixed inputs (optimal and real) and determine this way the rate of utilisation with respect to the economical optimum:

$$\frac{x_f^*}{x_f} \leq> 1 \qquad (6)$$

The associated structural efficiency will be given by:

$$0 \leq \frac{LRTC(\omega_v, \omega_f; y)}{VC(\omega_v, y, x_f) + \omega_f \cdot x_f} \leq 1 \qquad (7)$$

3.4. The Measurement of Frontier Efficiency in the Short- and Long–Run, and the Determination of Structural Efficiency

The model described above represents the usual cost minimisation problem and is only the first step for the evaluation of the rate of utilisation for the fixed inputs. So, taking as a starting point relation (1), and given a matrix of outputs (*Y*), of order *kxm*, a matrix of fixed inputs (X_f), of order kxn_1, and a matrix of variable inputs (X_v) of order kxn_2 ($n_1 + n_2 = n$), we can define, for every DMU_j, a production possibilities set $F(y_j)$ as a linear combination of the matrices described above:

$$F(y_j) = \{x_j : z \cdot Y \geq y_j, x_{fj} \geq z \cdot X_f, x_{vj} \geq z \cdot X_v, z \in R_+^k\} \qquad (8)$$

where $z = (z_1, z_2, ..., z_k)$ is the intensity vector (z≥0). Assuming as known the prices of inputs ($\omega_v, \omega_f \geq 0$) then it is possible to compute variable cost $[\omega_v \cdot x_v]$ and total cost $[\omega_v \cdot x_v + \omega_f \cdot x_f]$ for every firm in the sample.

Model 2

Once calculated variable, fixed and total costs we could define a short-run measure for the frontier efficiency (SRE) as being the coefficient between the minimum short-run total cost $\lfloor VC(\omega_v, y, x_f) + \omega_f \cdot x_f \rfloor$ and the total cost of the firm to be analysed $\lfloor \omega_v \cdot x_v + \omega_f \cdot x_f \rfloor$:

$$SRE(\omega_v, y, x_v, x_f) = \frac{VC(\omega_v, y, x_f) + \omega_f \cdot x_f}{\omega_v \cdot x_v + \omega_f \cdot x_f} \qquad (9)$$

The short-run variable cost (*VC)* is the optimal solution of the following minimisation programme:

$$\begin{aligned} & VC(\omega_v, y, x_f) = \min(\omega_v \cdot x_v^*) \qquad (10) \\ s.t.: \; & z \cdot Y \geq y \\ & x_v^* \geq z \cdot X_v \\ & x_f = z \cdot X_f \\ & \vec{1} \cdot z = 1 \end{aligned}$$

$$\text{and} \quad 0 \leq SRE \leq 1$$

At this point, it is worthwhile to mention that in programme [10] above, we consider the most extreme definition of the fixed assets constraint, ($x_f = z \cdot X_f$), instead of the more general case, ($x_f \geq z \cdot X_f$). Coming back to expression [9], a value of *SRE = 1* implies that the firm in question is performing in the short-run in the efficient cost frontier while a value of *SRE <1* will indicate us that the firm is not in the efficient short-run cost frontier. Then, the difference [*1 – SRE*] will give the magnitude of the reduction in costs that would locate the firm in the efficient cost frontier.

The result of the optimisation programme (10) is illustrated graphically in the Figures 1.a. and 1.b. below. In Figure 1.a. we present the average cost minimisation approach. In Figure 1.b. we give the equivalent situation but in an isoquant corresponding to the variable input set.

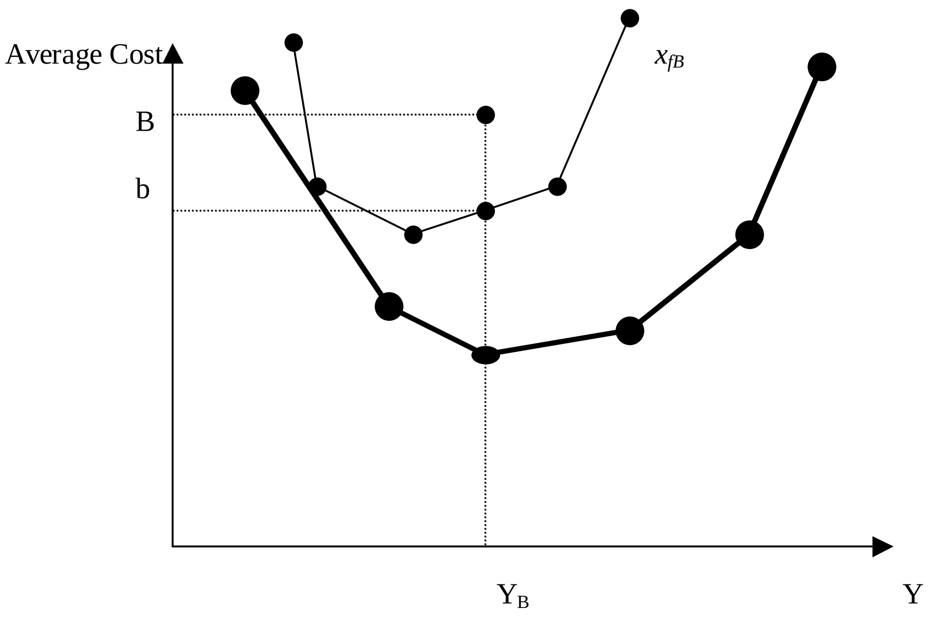

Figure 1.a. Short – Run Cost Efficiency – Average Cost Minimisation Approach

Assuming that it is not possible to adjust for the fixed inputs, after applying programme [10] we obtain point b and from the graph in Figure 1.a. it can be seen that point B (the observed average cost) is inefficient with respect to the short-run cost efficiency frontier (point b).

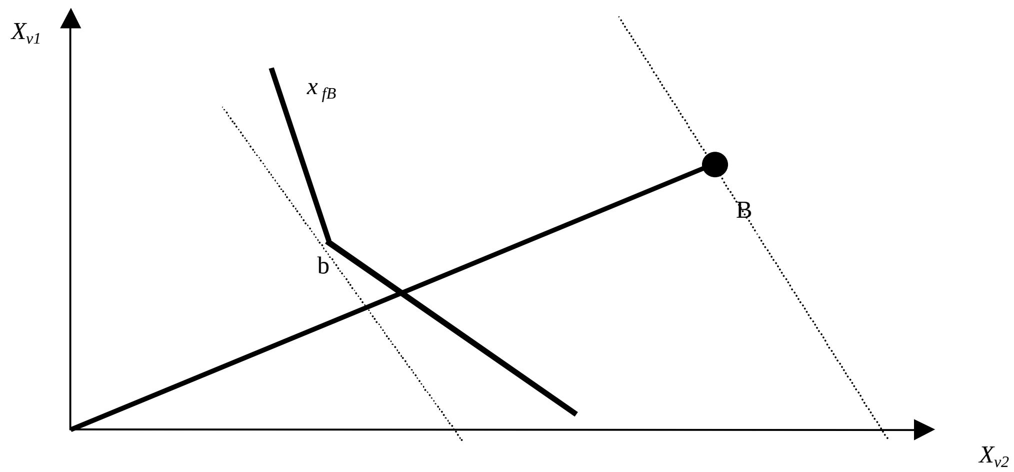

Figure 1.b. Short – Run Cost Efficiency - Variable Inputs Orientation Approach

Expression [10.1] presents the formalisation corresponding to points (B, b) in Figures 1.a. and 1.b. with two variable inputs and one fixed input.

$$
\begin{aligned}
&B = \omega_{v1} \cdot x_{v1}^{B} + \omega_{v2} \cdot x_{v2}^{B} + \omega_{f} \cdot x_{f}^{B} \\
&b = \omega_{v1} \cdot x_{v1}^{*} + \omega_{v2} \cdot x_{v2}^{*} + \omega_{f} \cdot x_{f}^{B} \\
&SRE(\omega_{v}, \omega_{f}, y, x_{v}, x_{f}) = \frac{b}{B} < 1
\end{aligned}
\qquad (10.1)
$$

In a similar manner we can compute the efficient cost frontier in the long - run (LRE) the only difference being given by the fact that now it is possible to adjust for the fixed inputs.

$$
LRE(\omega_{v}, \omega_{f}, y, x_{v}, x_{f}) = \frac{LRTC(\omega_{v}, \omega_{f}; y)}{\omega_{v} x_{v} + \omega_{f} x_{f}} \qquad (11)
$$

The numerator of expression (11) - the long-run total cost (*LRTC*)- will be given by the following minimisation programme:

$$
\begin{aligned}
&LRTC\ (\omega_{v}, \omega_{f}; y) = min\ (\omega_{v} \cdot x_{v}^{*} + \omega_{f} \cdot x_{f}^{*}) \\
&s.t.:\ \ z \cdot Y \geq y \\
&\quad x_{i}^{*} \geq z \cdot X_{i} \qquad i = \underbrace{1,\ldots,v}_{variable},\underbrace{v+1,\ldots,F}_{fixed\ \ inputs} \\
&\quad \vec{1} \cdot z = 1
\end{aligned}
\qquad (12)
$$

The graphical result of the optimisation programme [12] can be seen in Figures 2.a. and 2.b. In a setting similar to the one defined for figures 1.a. and 1.b., the programme evaluates the long-run cost efficiency frontier (LRCEF) represented by point D.

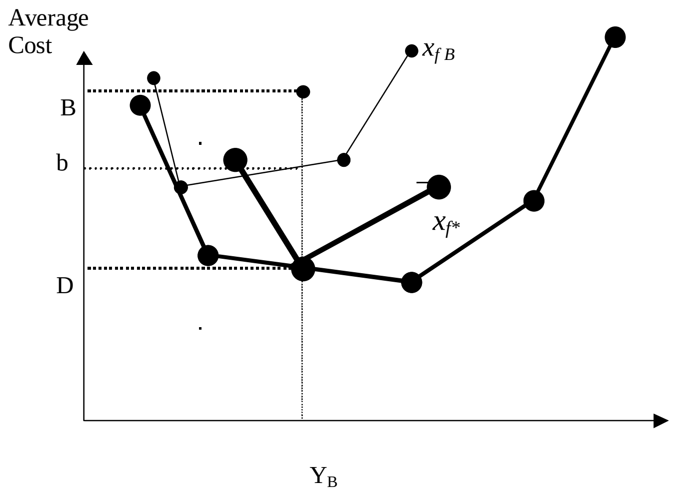

Figure 2.a. Long – Run Cost Efficiency – Average Cost Minimisation Approach

In the long - run we allow for adjustment of all fixed and variable inputs and point D is feasible. In Figure 2.b. we present the equivalent situation but in a variable input set. In contrast with the results presented in Figures 1.a. and 1.b., we see now how adjusting fixed inputs a lower cost can be obtained (D<b).

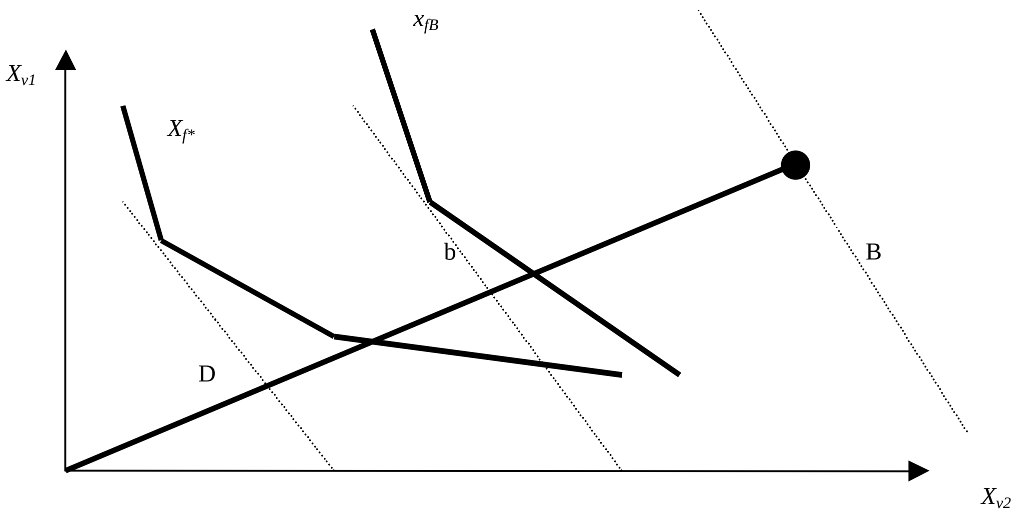

Figure 2.b. Long – Run Cost Efficiency - Variable Inputs Orientation Approach

Expression [12.1] gives the formalisation corresponding to points B and D for the particular case of two variable inputs and one fixed input.

$$B = \omega_{v1} \cdot x_{v1}^{B} + \omega_{v2} \cdot x_{v2}^{B} + \omega_{f} \cdot x_{f}^{B} \tag{12.1}$$
$$D = \omega_{v1} \cdot x_{v1}^{*} + \omega_{v2} \cdot x_{v2}^{*} + \omega_{f} \cdot x_{f}^{*}$$
$$LRE(\omega_{v}, \omega_{f}, y, x_{v}, x_{f}) = \frac{D}{B} < 1$$

Once known SRE and LRE the next step is to compute *structural efficiency (SE)*:

$$0 \leq \frac{LRE(\omega_{v}, \omega_{f}, y, x_{v}, x_{f})}{SRE(\omega_{v}, y, x_{v}, x_{f})} \leq 1 \tag{13}$$

In particular, for the case illustrated in Figures 1.a., 1.b. and 2.a., 2.b. if combine the SRE and LRE variables defined in expressions [10.1] and [12.1], SE is given by the following relation:

$$SE = \frac{LRE}{SRE} = \frac{D}{b} < 1 \tag{14}$$

Finally, the degree of *capacity utilisation for the fixed inputs* (*CU*) in the short-run is given by the expression below where, x_{f}^{*} stands for the required level of fixed inputs in order to minimise long-run total costs:

$$CU = \frac{x_{f}^{*}}{x_{f}} \lesssim 1 \tag{15}$$

A value of *CU=1* indicates that the actual physical capital (fixed inputs) corresponds to the long-run equilibrium level. If *CU* is significantly different from unity then the maintained level of fixed inputs does not minimise the total costs: (1) *CU <1* represents an excess of fixed inputs (under-utilisation of fixed inputs), and (2) *CU >1* reflects the fact that there is an over-utilisation of the fixed inputs. In particular, for the case presented in Figures 2.a. and 2.b., $CU = \frac{x_f^*}{x_f^B} > 1$ which means over-utilisation.

3.5. Data and Empirical Findings

For the empirical application we work with the same database already presented in detail in the first chapter. The variables selected for the analysis are presented in Table 1 below:

Table 1: Variables used in the analysis

	Output	**Fixed Costs**	**Variable Costs**
Short – Run	Turnover	Depreciation	Costs of employees Material expenses
Long - Run	Turnover		Costs of employees Material expenses Depreciation

For the adjustment of the capital input in the long-run we used the depreciation cost of capital (δ), calculated as the weight of the depreciation in the total amount of fixed assets, both variables expressed in absolute monetary terms. Another alternative would have been to correct the long-run capital input both with δ, and the interest rate on money (*i*). We decided to follow the first (traditional) approach and this was supported also by the fact that we did not find substantial differences between the two alternatives.

We did not apply a δ at firm level but rather worked for every year with an averaged δ ($\bar{\delta}$) calculated inside every industry sector on a country basis. Before calculating $\bar{\delta}$ we checked also for possible outliers with Tukey's Box-plot test. The values for $\bar{\delta}$ are given in the Appendix 3.1. at the end of the chapter. In Table 2 we give a sample of these values for one of the industry groups. As it can be seen from the results, the depreciation rates are particularly low for the two transition economies. This is true for each year from 1995 to 1998, and for all sectors.

Table 2: Sector 172 – Textile Weaving - $\bar{\delta}$ values

Country	1995	1996	1997	1998
Belgium	0.285	0.299	0.273	0.263
Bulgaria	0.105	0.113	0.013	0.195
France	0.342	0.315	0.329	0.325
Italy	0.215	0.214	0.207	0.230
Romania	0.031	0.036	0.075	0.067
Spain	0.231	0.192	0.219	0.227

We next estimate the CU degree in order to see if there is excess of capacity (CU<1) or on the contrary, there is over-utilisation (CU>1). The DEA methodology – programmes [10] and [12] – is applied in a variable returns to scale and input orientation setting given that we have a time horizon of only four years and due to the differences in the size of the analysed firms. The results concerning CU are presented in Appendix 3.2 and a sample of these results is presented in Table 3. We calculate global means both at sector and country level and to allow for a more correct interpretation of the results we distinguish between units exhibiting under-utilisation (CU<1) and over-utilisation (CU>1) of the existent capacity. In some cases (sectors 241 and 252), the presence of very large extreme values made necessary the application of a Tukey's Box-plot test.

Table 3: The Degree of Utilisation of the Fixed Inputs in the Short – Run (CU)

Sector 172 – Textile Weaving								
	1995		1996		1997		1998	
Indicators	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	1.8278	0.4062	2.0588	0.3192	1.6409	0.1870	2.5328	0.2257
Belgium	2.2376	0.3438	1.7252	0.2920	1.7287	0.2267	1.6887	0.2287
Bulgaria	-	0.4420	-	0.3486	1.3649	0.6426	-	0.2297
France	1.4405	0.3796	2.2171	0.4082	2.2608	0.2182	4.2996	0.2698
Italy	2.2184	0.4254	2.1929	0.2997	1.1757	0.2116	1.3636	0.2372
Romania	1.0158	0.4255	1.4448	0.3135	-	0.1037	1.0000	0.2155
Spain	1.5324	0.3133	1.8926	0.2697	-	0.1672	-	0.1198
Standard Deviation	1.4048	0.2532	1.5219	0.2276	1.0094	0.2265	3.2967	0.2247
Maximum Value	6.3569	0.9750	7.0211	0.9875	5.0170	0.9856	13.720	0.9813
Minimum Value	1.0000	0.0080	1.0000	0.0237	1.0000	0.0023	1.0000	0.0118
Number of Units with:								
CU < 1	136 (81%)		142 (84.5%)		143 (85.1%)		153 (91%)	
CU = 1	5 (2.9%)		4 (2.4%)		6 (3.6%)		6 (3.6%)	
CU > 1	27 (16.1%)		22 (13.1%)		19 (11.3%)		9 (5.4%)	
Total No. of Units	168		168		168		168	

According to our definition of CU-ratio of optimal to real level of fixed assets – the general picture is the following: on average, in four of the sectors analysed dominate the units with CU<1. These industrial sectors are: textile weaving (more than 80% of the total number of units over all the time period analysed exhibit under-utilisation of capacity), manufacturing of other textiles (more than 78%), manufacturing of rubber products (more than 65%), and manufacturing of plastic products (more than 60%). In the rest of the sectors – manufacturing of pulp, paper and paperboard (more than 56%) and manufacturing of basic chemicals (more than 65%) the dominant picture is of over- utilisation of the capacity. Concerning the case of CU = 1, the number of the units in this situation as it can be seen from Table 3, and Appendix 3.2. is very small. If we are to calculate the percentage corresponding to these units in each sector, we see that it does not go beyond 4%. For this reason, when report the results on CU degree, we do not distinguish among CU = 1 and CU>1 but present them instead all together as CU ≥1.

In the two sectors with over-utilisation, if look at the distribution of firms' CU per country the situation is the following: in sector 211 for example, for the market developed economies firms are distributed roughly speaking almost half and half between CU<1 and CU>1. France is slightly deviating from this tendency, the proportion being rather 1/3 for CU<1 to 2/3 CU>1. In Bulgaria, all firms exhibit CU ≥1. In Romania, firms are shifting from CU<1 to CU>1 and this proportion varies from about half-half in 1995 to more than 90% of the firms with CU>1 in 1998. In sector 241, the global tendency is indicating that the bulk of the firms (between 70-80%) in all countries (except for Bulgaria) exhibit CU>1, and the proportion is slightly growing from 1995 to 1998. In general, over-utilisation in a growing market could actually mean that firms in this situation exhibit an investing behaviour. In order to bring some empirical support to this hypothesis, we calculate also, for every sector, the growth rate of gross fixed assets (not adjusted for depreciation), in constant prices of 1995, and the results are given in Appendix 3.3. A sample of these estimates is presented in Table 4, bellow for one of the sectors.

The intuition behind is the following: when CU>1, firms are in need of capacity that is to say there is incentive for investment in fixed assets. So, we would expect the growth rate of fixed assets when CU>1 to be greater than when CU<1. We present the results in a matrix format, calculating positive and negative growth rates of fixed assets separately for units with CU<1 and CU ≥1. The figures in Table 4, go in line with the intuition explained earlier: in average, positive growth rates of fixed assets are greater when CU ≥1 than when CU<1. In other words, in a growing market, firms with over – utilization of the capacity are investing in fixed assets, and in the contrary disinvesting or may be transferring fixed assets to other sectors when GRFA is negative.

Table 4: Sector 172 – Growth Rates of Fixed Assets (GRFA)

No. units with.	GRFA 95 - 96		No. units with:	GRFA 96 – 97		No. Units with:	GRFA 97 - 98	
	+	-		+	-		+	-
CU<1 (136)	0.2784 (34)	-0.3764 (102)	**CU<1 (142)**	0.4425 (19)	-0.3973 (123)	**CU<1 (143)**	0.3222 (63)	-0.3084 (80)
CU≥1 (32)	6.8713 (16)	-0.1629 (16)	**CU≥1 (26)**	0.5972 (11)	-0.2311 (15)	**CU≥1 (25)**	0.3106 (20)	-0.1370 (5)

For the rest of the sectors the same conclusion holds with one exception, group 251. Still in this case as it can be seen from the corresponding table in Appendix 3.3., the fact that the growth rate of fixed assets when CU ≥1 is not bigger than the growth rate when CU<1 is also explained by the fact that the units exhibiting CU ≥1 are very few (i.e., 6 against 133, for GRFA in 1995/96).

If put into relation the degree of capacity utilization and the growth rate of fixed assets, it is possible to identify four general *business environment* situations, summarized in the next table. As can be seen, most of the sectors can be found in quadrants two and three of the table.

Table 5: CU vs. GRFA Relationship and the Business Environment

	+ GRFA	**- GRFA**
CU < 1	- growing markets; - firms investing; - firms not using full capacity; Sector 251	- decreasing markets; - firms disinvesting; - excess of capacity; Sectors 172, 175, 241
CU ≥ 1	- growing markets; - over-utilisation of capacity; - growing investment; Sectors 172, 175, 211, 241, 252	- mature markets; Sectors 211, 251, 252

We present also cost analysis results in Appendix 3.4. A sample of results is presented in Table 6. We calculated three indicators: the short and long-run average level of cost efficiency (SRE, LRE) and the structural efficiency (SE) ratio. The first two indicators mentioned above (SRE) and (LRE), by definition, cannot take greater values than unity (100%). The differences [1-SRE] and [1-LRE] respectively, represent the reduction in costs that would locate the unit in the efficient cost frontier (that is to say the potential cost savings) in the short and long-run. For all sectors, both indicators have in average values bellow unity which means cost inefficiency.

Table 6: Average Cost Efficiency Results – Sector 172

Indicators	**1995**	**1996**	**1997**	**1998**
Long-Run Efficiency (LRE)	0.4824	0.5530	0.5583	0.5149
Minimum Value	0.0434	0.2952	0.1772	0.2719
LRE<100 (No. of Units)	163 (97%)	164 (97.5%)	162 (96%)	162 (96%)
LRE=100 (No. of Units)	5 (3%)	4 (2.5%)	6 (4%)	6 (4%)
Short-Run Efficiency (SRE)	0.5754	0.6348	0.6376	0.6167
Minimum Value	0.3350	0.4136	0.3895	0.3470
SRE<100 (No. of Units)	155 (92%)	153 (91%)	164 (97.5%)	163 (97%)
SRE=100 (No. of Units)	13 (8%)	15 (9%)	4 (2.5%)	5 (3%)
Structural Efficiency (SE)	0.8536	0.8879	0.8833	0.8499
Minimum Value	0.0434	0.2952	0.1772	0.3639
SE<100 (No. of Units)	163 (97%)	164 (97.5%)	165 (98%)	166 (99%)
SE=100 (No. of Units)	5 (3%)	4 (2.5%)	3 (2%)	2 (1%)
Total Number of Units	168	168	168	168

The long-run values are relatively smaller than in the short-run which implies more cost inefficiency. As a consequence of both measures of cost efficiency – in the short- and long-run – being smaller than unit, almost all units exhibit in average SE<1. So they have cost excess due to an inadequate fixed assets factor endowment in the short-run. This is also supported by the fact that the percentage of the units with an optimal level of fixed assets is quite small, bellow 5%.

Analysing the evolution of the indicators from 1995 to 1998 the general tendency is of cost inefficiency relative reduction, in particular this can be noticed from 1995 to 1997 with a slight increase in 1998. The cost efficiency analysis confirmed the previous results on CU. Most of the firms have CU<1 which means excess of capacity hence cost excess.

3.6. Concluding Remarks

The analysis performed in this chapter is intended to have several contributions. The first one is the proposal of cost inefficiency estimation, applied within a non-parametric setting. The differences in cost among firms could be explained considering mainly two approaches: analysing the size of the firms or the level of fixed inputs. In this chapter we deal with the problem of fixed inputs and the capacity utilisation as influential factor, provided that the literature sorted out the first approach long ago.

The second contribution relates to the empirical application in itself. Total Factor Productivity (TFP) is a standard measure widely used in many empirical studies concerning the well-established market economies but has not been used to a large extent in transition economies for which there is not that much work done on productivity analysis, in a non – parametric framework, in particular.

Third, our empirical results allow us to contrast our conclusions with previous survey findings with respect to the following aspects: a) it is generally accepted that the transition economies needed to invest heavily in the modernisation of their obsolete capital stock and become this way competitive on world markets; b) another aspect refers to an important but so far open debate about the performance and investment behaviour which are different among private, public, and other type of firms; c) the credit policy in transition economies is more restrictive, once the state is not subsidising the former state-owned enterprises, and this is valid also for public enterprises in the developed market economies. In other words, focusing on the supply side of investment, it is possible to test the credit rationing hypothesis advanced in the western literature but also put forth in transition economies especially in the early period. The intuition behind is that the investment behaviour of the firms is linked to the financial availability. In fact, this last aspect will be analysed in more detail in the next chapter.

Resuming, the main empirical findings are the following: 1) on average, in most of the cases (2 groups in textile industry and 2 in chemistry) the prevalent situation is the under-utilisation of the existent capacity. This excess of capacity generates cost inefficiency stimulated at the same time by a slow-down in the domestic demand.

These results, actually confirm in part our previous way of thinking about this subject: the more physical capital the more under-utilisation and the greater the importance of fixed assets in accounting balance sheets.

Nevertheless, whenever there is over-utilisation, this is associated in most of the cases with a positive growth rate of fixed assets which means that a small number of firms also invest in capital. At country level, this investment policy is unbalanced in the sense that this is actually verified for the market economies. The transition countries have to catch-up and urge to become more competitive but the path of investment is much slower. Both in Bulgaria and Romania most of the former state enterprises have been restructured as joint-stock companies. This in fact means that many of them are a result of the massive and urgent transformation because of the forthcoming privatisation, and not so much a result of the development of the market mechanisms. Hence, we can speak about ownership restructuring but this does not necessarily imply capital investment.

It is worthwhile to mention that one of the models followed by the privatisation processes in the two countries was the participation of employees and managers of the company. It is generally agreed that this method is not the best to face the restructuring demands of a transition economy. The reason is that employees may lack the adequate skills and capital to restructure firms.[18] To this we have to add also that the privatisation process overall, with its legal provisions and sometimes lack of transparency, did not especially stimulate the rapid creation and development of competitive financial markets in these countries. A consequence of this was the restricted access to credits of the newly privatised firms. In the next chapter we will analyse more in detail the impact of financial constraints on firms' performance.

Related to the ownership forms we have to say that in our case given that the bulk of the firms are public, and a very small percentage are private or of other type, this makes less relevant any conclusion about the relationship between owner-type and investment behaviour and/or cost inefficiency.

[18] In many cases this privatisation contracts contained provisions in order to prevent changes in the level of employment and in the main activity of the firm, and these restrictions made difficult or even impossible a substantial restructuring of the firms.

Finally, the research was somehow complicated also by the fact that apart from working with data on transition economies characterised by a high inflation in the period analysed, we face the very common problem of most part of the non-parametric research that is, the impossibility of measuring the *real cost* frontier. We found that almost all units exhibit in average a structural efficiency coefficient bellow unit. This means that firms may have cost excess due to an inadequate fixed assets factor endowment in the short-run. But, as we operate with the *empirical cost* frontier and not the *real* one, it could be also that the reference units, perform on the frontier because they simply manage better their variable inputs without optimising actually, the level of the fixed inputs. This issue is not treated here but it deserves further investigation.

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Appendix 3.1.

The Depreciation Cost of Capital

- $\bar{\delta}$ -

Sector 172 – Textile Weaving

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.285	0.299	0.273	0.263
Bulgaria	0.105	0.113	0.013	0.195
France	0.342	0.315	0.329	0.325
Italy	0.215	0.214	0.207	0.230
Romania	0.031	0.036	0.075	0.067
Spain	0.231	0.192	0.219	0.227

Sector 175 – Manufacturing of other Textiles

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.322	0.361	0.372	0.355
Bulgaria	0.052	0.112	0.009	0.088
France	0.284	0.305	0.324	0.305
Italy	0.261	0.274	0.256	0.270
Netherlands	0.165	0.169	0.160	0.152
Romania	0.029	0.035	0.055	0.049
Spain	0.202	0.168	0.210	0.186

Sector 211 – Manufacture of Pulp, Paper and Paperboard

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.166	0.201	0.183	0.196
Bulgaria	0.081	0.110	0.012	0.076
France	0.227	0.252	0.244	0.254
Italy	0.187	0.201	0.206	0.206
Netherlands	0.167	0.180	0.164	0.173
Romania	0.036	0.029	0.058	0.055
Spain	0.161	0.140	0.147	0.157

Sector 241 – Manufacturing of Basic Chemicals

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.230	0.202	0.189	0.190
Bulgaria	0.050	0.061	0.008	0.089
France	0.218	0.220	0.226	0.221
Italy	0.217	0.203	0.217	0.352
Netherlands	0.148	0.154	0.151	0.147
Romania	0.030	0.029	0.052	0.046
Spain	0.132	0.118	0.144	0.149

Sector 251 – Manufacturing of Rubber Products

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.418	0.357	0.383	0.380
Bulgaria	0.062	0.103	0.007	0.109
France	0.213	0.332	0.331	0.332
Italy	0.213	0.231	0.225	0.242
Netherlands	0.176	0.177	0.164	0.163
Romania	0.026	0.031	0.057	0.051
Spain	0.149	0.133	0.189	0.175

Sector 252 – Manufacturing of Plastic Products

Country	**1995**	**1996**	**1997**	**1998**
Belgium	0.355	0.376	0.339	0.352
Bulgaria	0.068	0.084	0.011	0.092
France	0.298	0.307	0.291	0.279
Italy	0.223	0.225	0.221	0.219
Netherlands	0.152	0.151	0.149	0.140
Romania	0.030	0.031	0.054	0.046
Spain	0.167	0.169	0.194	0.190

Appendix 3.2.

The Degree of Utilisation of the Fixed Inputs in the Short – Run (CU)

Sector 172 – Textile Weaving

	1995		1996		1997		1998	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**1.8278**	**0.4062**	**2.0588**	**0.3192**	**1.6409**	**0.1870**	**2.5328**	**0.2257**
Belgium	2.2376	0.3438	1.7252	0.2920	1.7287	0.2267	1.6887	0.2287
Bulgaria	-	0.4420	-	0.3486	1.3649	0.6426	-	0.2297
France	1.4405	0.3796	2.2171	0.4082	2.2608	0.2182	4.2996	0.2698
Italy	2.2184	0.4254	2.1929	0.2997	1.1757	0.2116	1.3636	0.2372
Romania	1.0158	0.4255	1.4448	0.3135	-	0.1037	1.0000	0.2155
Spain	1.5324	0.3133	1.8926	0.2697	-	0.1672	-	0.1198
Standard deviation	1.4048	0.2532	1.5219	0.2276	1.0094	0.2265	3.2967	0.2247
Maximum Value	6.3569	0.9750	7.0211	0.9875	5.0170	0.9856	13.720	0.9813
Minimum Value	1.0000	0.0080	1.0000	0.0237	1.0000	0.0023	1.0000	0.0118
Total no. of Units	32	136	26	142	25	143	15	153

CU – Number of units with:

	1995			1996			1997			1998		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	16	0	4	18	0	2	18	0	2	18	0	2
Bulgaria	8	0	0	8	0	0	4	1	3	8	0	0
France	17	2	6	19	1	5	16	2	7	19	2	4
Italy	44	1	12	45	2	10	47	3	7	52	2	3
Romania	45	2	1	46	1	1	48	0	0	46	2	0
Spain	6	0	4	6	0	4	10	0	0	10	0	0
Total	136	5	27	142	4	22	143	6	19	153	6	9

Sector 175 – Manufacturing of other Textiles

	1995		1996		1997		1998	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**2.5247**	**0.2520**	**1.7239**	**0.1981**	**2.3957**	**0.2490**	**1.8202**	**0.2753**
Belgium	1.9080	0.2639	1.1246	0.2307	1.4627	0.1960	1.4797	0.2702
Bulgaria	-	0.2205	-	0.3005	4.5461	-	1.0262	0.4716
France	1.0650	0.2675	1.4939	0.2144	1.5546	0.1981	1.2151	0.2711
Italy	2.8537	0.2437	1.9511	0.1849	2.2222	0.1932	2.1050	0.2013
Netherlands	1.0716	0.4678	1.0000	0.3907	1.0000	0.5483	1.0000	0.5507
Romania	1.3922	0.2241	1.2431	0.1830	1.5017	0.4301	1.7681	0.4611
Spain	6.1687	0.2752	2.6107	0.1342	4.6110	0.1718	2.4408	0.1780
Standard deviation	2.9999	0.1987	1.0133	0.2085	2.0724	0.2492	1.1273	0.2194
Maximum Value	12.426	0.9527	4.2147	0.9908	8.9633	0.9674	6.0658	0.9375
Minimum Value	1.0000	0.0213	1.0000	0.0088	1.0000	0.0101	1.0000	0.0148
Total no. of Units	22	143	20	145	25	140	37	128

CU – Number of units with:

	1995			1996			1997			1998		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	28	0	1	28	0	1	28	0	1	28	0	1
Bulgaria	3	0	0	3	0	0	0	0	3	2	0	1
France	19	1	2	20	1	1	20	1	1	19	1	2
Italy	44	4	4	46	2	4	46	2	4	44	1	7
Netherlands	2	1	1	2	2	0	3	1	0	3	1	0
Romania	33	2	3	33	2	3	29	2	7	19	2	17
Spain	14	0	3	13	0	4	14	0	3	13	0	4
Total	143	8	14	145	7	13	140	6	19	128	5	32

Sector 211 - Manufacturing of Pulp, Paper and Paperboard

	1995		1996		1997		1998	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**2.0283**	**0.6472**	**2.1718**	**0.6078**	**2.5605**	**0.6716**	**2.0198**	**0.6576**
Belgium	2.0077	0.5814	1.8499	0.6208	2.0418	0.6732	1.8505	0.7213
Bulgaria	1.8247	-	2.1212	-	10.260	-	1.3721	-
France	1.8269	0.6256	1.8063	0.5596	1.7537	0.5877	1.7192	0.6135
Italy	2.3273	0.6257	1.8361	0.5792	2.1395	0.6401	2.0799	0.6233
Netherlands	1.2164	0.5402	1.1972	0.5176	1.1613	0.7947	1.0758	0.8300
Romania	1.5070	0.6991	3.3383	-	3.6521	0.8690	2.4137	0.6074
Spain	2.2021	0.7310	2.6047	0.7349	2.5940	0.7906	2.4563	0.7217
Standard deviation	1.3141	0.2177	2.0179	0.2419	3.1006	0.2161	1.5328	0.1979
Maximum Value	7.2225	0.9916	15.972	0.9910	22.421	0.9902	11.520	0.9770
Minimum Value	1.0000	0.1269	1.0000	0.1252	1.0000	0.1219	1.0000	0.1579
Total no. of Units	83	66	89	60	107	42	97	52

CU – Number of units with:

	1995			1996			1997			1998		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	3	0	6	5	0	4	3	0	6	4	0	5
Bulgaria	0	0	4	0	1	3	0	1	3	0	1	3
France	12	1	20	12	1	20	7	2	24	9	1	23
Italy	29	1	25	29	1	25	22	1	32	25	1	29
Netherlands	3	1	2	2	1	3	2	1	3	2	1	3
Romania	6	1	5	0	0	12	1	0	11	1	0	11
Spain	13	1	16	12	0	18	7	0	23	11	0	19
Total	66	5	78	60	4	85	42	5	102	52	4	93

Sector 241 – Manufacturing of Basic Chemicals

	1995		**1996**		**1997**		**1998**	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**2.8306**	**0.6337**	**2.8928**	**0.6592**	**3.0072**	**0.5772**	**3.3710**	**0.6129**
Belgium	3.0394	0.5771	2.8766	0.6190	3.7347	0.6157	3.3696	0.7150
Bulgaria	3.6349	0.5466	3.6218	0.9671	4.7788	0.8053	1.0000	0.1608
France	3.1325	0.5753	3.1374	0.6553	2.8779	0.5831	4.2024	0.6916
Italy	2.3362	0.6921	2.2572	0.6831	2.7481	0.5657	2.1801	0.6543
Netherlands	2.9987	0.9891	3.2557	0.9260	2.4410	0.9946	3.3219	-
Romania	3.0229	0.6057	3.5945	0.6003	2.5222	0.5522	4.1769	0.4833
Spain	3.2764	0.8291	2.7317	-	3.7889	0.5604	3.2565	0.7777
Standard deviation	1.7279	0.2345	1.8516	0.2345	2.1992	0.2468	2.4869	0.2592
Maximum Value	8.4615	0.9993	11.268	0.9804	13.415	0.9990	13.568	0.9992
Minimum Value	1.0000	0.1127	1.0000	0.1381	1.0000	0.0330	1.0000	0.0474
Extreme Values	20	-	20	-	20	-	18	2
Total no. of Units	213	51	210	54	187	77	212	52

CU – Number of units with:

	1995			**1996**			**1997**			**1998**		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	15	1	19	12	2	21	9	1	25	7	1	27
Bulgaria	2	0	3	1	1	3	1	1	3	4	1	0
France	9	0	47	14	0	41	9	2	45	8	1	47
Italy	12	1	75	18	2	69	25	1	62	26	1	61
Netherlands	2	0	6	1	0	7	1	0	7	0	0	8
Romania	9	1	44	8	1	45	27	1	26	6	0	48
Spain	2	2	14	0	1	17	5	1	12	1	1	16
Total	51	5	208	54	7	203	77	7	180	52	5	207

Sector 251 – Manufacturing of Rubber Products

	1995		1996		1997		1998	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**1.0571**	**0.0134**	**1.9084**	**0.4018**	**2.3364**	**0.4525**	**1.1184**	**0.0402**
Belgium	-	0.0016	-	0.4733	-	0.4885	-	0.0031
Bulgaria	-	0.0030	1.3724	0.0419	3.1123	-	-	0.0888
France	1.0000	0.0045	2.7575	0.3547	2.8046	0.3864	1.0000	0.0071
Italy	1.0000	0.0022	1.3046	0.3921	2.3591	0.4571		0.0267
Netherlands	1.0000	0.0005	1.0000	0.1150	1.0000	0.1528	1.0000	0.0011
Romania	1.0000	0.0426	1.8530	0.5968	2.0217	0.6254	1.2762	0.1227
Spain	1.3426	0.0162	1.3851	0.4549	1.1332	0.4081	1.0000	0.0183
Standard deviation	0.1399	0.0540	1.4017	0.2753	2.0475	0.2937	0.3131	0.1144
Maximum Value	1.3426	0.5137	9.4454	0.9704	11.370	0.9937	1.8285	0.9989
Minimum Value	1.0000	0.0003	1.0000	0.0005	1.0000	0.0010	1.0000	0.0007
Total no. of Units	6	133	49	90	45	94	7	132

CU – Number of units with:

	1995			1996			1997			1998		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	4	0	0	4	0	0	4	0	0	4	0	0
Bulgaria	2	0	0	1	0	1	0	1	1	2	0	0
France	39	0	2	29	1	11	26	2	13	39	1	1
Italy	42	1	0	34	1	8	34	1	8	43	0	0
Netherlands	2	1	0	2	1	0	2	1	0	2	1	0
Romania	30	1	0	9	1	21	15	1	15	28	2	1
Spain	14	0	1	11	1	3	13	1	1	14	1	0
Total	133	3	3	90	5	44	94	7	38	132	5	2

Sector 252 – Manufacturing of Plastic Products

	1995		1996		1997		1998	
	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1	CU≥1	CU<1
Global Mean	**1.7874**	**0.5843**	**1.6183**	**0.4315**	**1.6596**	**0.5021**	**1.8985**	**0.5992**
Belgium	1.4043	0.4905	1.2181	0.2943	1.4842	0.3947	1.4112	0.5332
Bulgaria	1.5857	0.4777	1.0747	-	2.1411	-	1.5764	0.5521
France	1.6275	0.6166	1.6425	0.4426	1.5500	0.5704	1.8023	0.6521
Italy	1.6889	0.6166	1.2777	0.4219	1.6321	0.5153	1.7029	0.6186
Netherlands	1.2581	0.5794	1.6437	0.5266	1.5701	0.5362	1.3399	0.6902
Romania	1.8464	0.6085	1.8455	0.6162	1.6137	0.5413	2.2133	0.6161
Spain	2.0197	0.5951	1.8654	0.3967	1.9833	0.4184	2.4348	0.5177
Standard deviation	0.9218	0.2268	0.7228	0.2341	0.7680	0.2288	1.0304	0.2276
Maximum Value	5.9991	0.9971	4.2545	0.9865	5.1519	0.9832	6.2404	0.9992
Minimum Value	1.0000	0.0409	1.0000	0.0349	1.0000	0.0389	1.0000	0.0211
Extreme Values	18	-	17	1	17	1	14	4
Total no. of Units	172	284	79	377	137	319	179	277

CU – Number of units with:

	1995			1996			1997			1998		
	CU<1	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**	**CU<1**	**CU=1**	**CU>1**
Belgium	41	0	6	46	0	1	41	0	6	40	0	7
Bulgaria	3	0	2	0	0	3	0	2	3	3	0	2
France	66	4	33	86	2	15	65	2	36	54	0	49
Italy	102	0	66	151	1	16	128	0	40	107	1	60
Netherlands	5	1	2	5	1	2	4	1	3	5	2	1
Romania	33	0	34	43	0	24	40	0	27	30	1	36
Spain	34	0	24	46	0	12	41	0	17	38	0	20
Total	284	5	167	377	4	75	319	5	132	277	4	175

Appendix 3.3.

Growth Rates of Fixed Assets (GRFA)

Sector 172 – Textile Weaving

No. units with.	GRFA 95 - 96		No. units with:	GRFA 96 – 97		No. Units with:	GRFA 97 - 98	
	+	-		+	-		+	-
CU<1 (136)	0.2784 (34)	-0.3764 (102)	**CU<1 (142)**	0.4425 (19)	-0.3973 (123)	**CU<1 (143)**	0.3222 (63)	-0.3084 (80)
CU≥1 (32)	6.8713 (16)	-0.1629 (16)	**CU≥1 (26)**	0.5972 (11)	-0.2311 (15)	**CU≥1 (25)**	0.3106 (20)	-0.1370 (5)

Sector 175 – Manufacturing of Other Textiles

Units with:	GRFA 95 - 96		Units with:	GRFA 96 – 97		Units with:	GRFA 97 - 98	
	+	-		+	-		+	-
CU<1 (143)	0.3965 (46)	-0.3076 (97)	**CU<1 (145)**	0.2762 (33)	-0.3430 (112)	**CU<1 (140)**	0.3259 (85)	-0.2470 (55)
CU≥1 (22)	0.4843 (10)	-0.1888 (12)	**CU≥1 (20)**	0.4261 (6)	-0.2592 (14)	**CU≥1 (25)**	0.6695 (16)	-0.3159 (9)

Sector 211 – Manufacturing of Pulp, Paper and Paperboard

Units with:	GRFA 95 - 96		Units with:	GRFA 96 – 97		Units with:	GRFA 97 - 98	
	+	-		+	-		+	-
CU<1 (66)	0.3198 (40)	-0.1862 (26)	**CU<1 (60)**	0.2478 (11)	-0.1606 (49)	**CU<1 (42)**	0.1468 (20)	-0.0729 (22)
CU≥1 (83)	0.3618 (52)	-0.2816 (31)	**CU≥1 (89)**	0.6297 (33)	-0.2839 (56)	**CU≥1 (107)**	0.3863 (61)	-0.1776 (46)

Sector 241 – Manufacturing of Basic Chemicals

Units with:	GRFA 95 - 96 +	GRFA 95 - 96 -	Units with:	GRFA 96 – 97 +	GRFA 96 – 97 -	Units with:	GRFA 97 - 98 +	GRFA 97 - 98 -
CU<1 (51)	0.4807 (16)	-0.2596 (35)	**CU<1 (54)**	0.1837 (5)	-0.2401 (49)	**CU<1 (77)**	0.2074 (40)	-0.2853 (37)
CU≥1 (213)	0.3711 (104)	-0.2992 (109)	**CU≥1 (210)**	0.2637 (40)	-0.3466 (170)	**CU≥1 (187)**	0.2193 (127)	-0.1841 (60)

Sector 251 – Manufacturing of Rubber Products

Units with:	GRFA 95 - 96 +	GRFA 95 - 96 -	Units with:	GRFA 96 – 97 +	GRFA 96 – 97 -	Units with:	GRFA 97 - 98 +	GRFA 97 - 98 -
CU<1 (133)	0.2896 (58)	-0.3011 (75)	**CU<1 (90)**	0.1896 (16)	-0.2327 (74)	**CU<1 (94)**	0.2392 (62)	-0.2126 (32)
CU≥1 (6)	0.1601 (4)	-0.1918 (2)	**CU≥1 (49)**	1.1860 (9)	-0.4753 (40)	**CU≥1 (45)**	0.2186 (23)	-0.2714 (22)

Sector 252 – Manufacturing of Plastic Products

Units with:	GRFA 95 - 96 +	GRFA 95 - 96 -	Units with:	GRFA 96 – 97 +	GRFA 96 – 97 -	Units with:	GRFA 97 - 98 +	GRFA 97 - 98 -
CU<1 (284)	0.2982 (115)	-0.2159 (169)	**CU<1 (377)**	0.2388 (85)	-0.2449 (292)	**CU<1 (319)**	0.3123 (110)	-0.1790 (209)
CU≥1 (172)	1.0711 (82)	-0.2906 (90)	**CU≥1 (79)**	0.3066 (14)	-0.3804 (65)	**CU≥1 (137)**	0.3724 (85)	-0.2225 (52)

Appendix 3.4.

Average Cost Efficiency

Sector 172 – Textile Weaving

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.4824	0.5530	0.5583	0.5149
Minimum Value	0.0434	0.2952	0.1772	0.2719
LRE<100 (No. of Units)	163 (97%)	164 (97.5%)	162 (96%)	162 (96%)
LRE=100 (No. of Units)	5 (3%)	4 (2.5%)	6 (4%)	6 (4%)
Short-Run Efficiency (SRE)	0.5754	0.6348	0.6376	0.6167
Minimum Value	0.3350	0.4136	0.3895	0.3470
SRE<100 (No. of Units)	155 (92%)	153 (91%)	164 (97.5%)	163 (97%)
SRE=100 (No. of Units)	13 (8%)	15 (9%)	4 (2.5%)	5 (3%)
Structural Efficiency (SE)	0.8536	0.8879	0.8833	0.8499
Minimum Value	0.0434	0.2952	0.1772	0.3639
SE<100 (No. of Units)	163 (97%)	164 (97.5%)	165 (98%)	166 (99%)
SE=100 (No. of Units)	5 (3%)	4 (2.5%)	3 (2%)	2 (1%)
Total Number of Units	168	168	168	168

Sector 175 – Manufacturing of other Textiles

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.5335	0.5453	0.5419	0.4991
Minimum Value	0.1964	0.3152	0.3255	0.2927
LRE<100 (No. of Units)	158 (95.75%)	158 (95.75%)	159 (96%)	160 (97%)
LRE=100 (No. of Units)	7 (4.25%)	7 (4.25%)	6 (4%)	5 (3%)
Short-Run Efficiency (SRE)	0.6307	0.6448	0.6384	0.6066
Minimum Value	0.2128	0.3943	0.3376	0.3258
SRE<100 (No. of Units)	145 (88%)	160 (97%)	160 (97%)	158 (95.75%)
SRE=100 (No. of Units)	20 (12%)	5 (3%)	5 (3%)	7 (4.25%)
Structural Efficiency (SE)	0.6307	0.8581	0.8646	0.8404
Minimum Value	0.2128	0.3803	0.3418	0.2927
SE<100 (No. of Units)	158 (95.75%)	158 (95.75%)	161 (98%)	161 (98%)
SE=100 (No. of Units)	7 (4.25%)	7 (4.25%)	4 (2%)	4 (2%)
Total Number of Units	165	165	165	165

Sector 211 – Manufacturing of Pulp, Paper and Paperboard

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.6975	0.6632	0.7185	0.7065
Minimum Value	0.4815	0.4683	0.4936	0.5181
LRE<100 (No. of Units)	144 (96.5%)	145 (97%)	144 (96.5%)	144 (96.5%)
LRE=100 (No. of Units)	5 (3.5%)	4 (3%)	5 (3.5%)	5 (3.5%)
Short-Run Efficiency (SRE)	0.7745	0.7524	0.7855	0.7582
Minimum Value	0.5392	0.5319	0.5018	0.5237
SRE<100 (No. of Units)	129 (87%)	145 (97%)	141 (95%)	139 (93%)
SRE=100 (No. of Units)	20 (13%)	4 (3%)	8 (5%)	10 (7%)
Structural Efficiency (SE)	0.9096	0.8890	0.9200	0.9395
Minimum Value	0.5496	0.5244	0.5467	0.5581
SE<100 (No. of Units)	144 (96.5%)	145 (97%)	147 (99%)	147 (99%)
SE=100 (No. of Units)	5 (3.5%)	4 (3%)	2 (1%)	2 (1%)
Total Number of Units	149	149	149	149

Sector 241 – Manufacturing of Basic Chemicals

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.5032	0.5116	0.6256	0.5348
Minimum Value	0.2926	0.2425	0.2251	0.0442
LRE<100 (No. of Units)	279 (98%)	279 (98%)	278 (97.5%)	279 (98%)
LRE=100 (No. of Units)	5 (2%)	5 (2%)	6 (2.5%)	5 (2%)
Short-Run Efficiency (SRE)	0.6422	0.6420	0.7159	0.6523
Minimum Value	0.3880	0.3535	0.3464	0.1060
SRE<100 (No. of Units)	264 (93%)	273 (96%)	266 (94%)	271 (95%)
SRE=100 (No. of Units)	20 (7%)	11 (4%)	18 (6%)	13 (5%)
Structural Efficiency (SE)	0.7990	0.8151	0.8863	0.8268
Minimum Value	0.3963	0.3862	0.3327	0.1507
SE<100 (No. of Units)	279 (98%)	282	278 (97.5%)	282 (99%)
SE=100 (No. of Units)	5 (2%)	2	6 (2.5%)	3 (1%)
Total Number of Units	284	284	284	284

Sector 251 – Manufacturing of Rubber Products

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.6950	0.7009	0.7262	0.7391
Minimum Value	0.4922	0.4947	0.5069	0.4311
LRE<100 (No. of Units)	134 (96%)	133 (95.5%)	132 (95%)	133 (95.5%)
LRE=100 (No. of Units)	5 (4%)	6 (4.5%)	7 (5%)	6 (4.5%)
Short-Run Efficiency (SRE)	0.7322	0.7399	0.7634	0.7820
Minimum Value	0.4973	0.5306	0.5145	0.5376
SRE<100 (No. of Units)	129 (93%)	134 (96%)	134 (96%)	129 (93%)
SRE=100 (No. of Units)	10 (7%)	5 (4%)	5 (4%)	10 (7%)
Structural Efficiency (SE)	0.9517	0.9496	0.9538	0.9486
Minimum Value	0.7169	0.7062	0.7124	0.5642
SE<100 (No. of Units)	134 (96%)	136 (98%)	135 (97%)	137 (98.5%9
SE=100 (No. of Units)	5 (4%)	3 (2%)	4 (3%)	2 (1.5%)
Total Number of Units	139	139	139	139

Sector 252 – Manufacturing of Plastic Products

	1995	1996	1997	1998
Long-Run Efficiency (LRE)	0.5917	0.5595	0.4904	0.5967
Minimum Value	0.3348	0.2991	0.2932	0.1466
LRE<100 (No. of Units)	468 (98.5%)	468 (98.5%)	469 (99%)	468 (98.5%)
LRE=100 (No. of Units)	6 (1.5%)	6 (1.5%)	5 (1%)	6 (1.5%)
Short-Run Efficiency (SRE)	0.6391	0.6279	0.5740	0.6406
Minimum Value	0.4478	0.4245	0.3279	0.3383
SRE<100 (No. of Units)	455 (96%)	468 (98.5%)	467 (98%)	461 (97%)
SRE=100 (No. of Units)	19 (4%)	6 (1.5%)	7 (2%)	13 (3%)
Structural Efficiency (SE)	0.9354	0.9043	0.8679	0.9406
Minimum Value	0.3348	0.3433	0.2932	0.1466
SE<100 (No. of Units)	468 (98.5%)	469 (99%)	472 (99.5%)	472 (99.5%)
SE=100 (No. of Units)	6 (1.5%)	5 (1%)	2 (0.5%)	2 (0.5%)
Total Number of Units	474	474	474	474

Chapter 4

A Non-Parametric Directional Distance Function Approach to Constrained Profit Maximisation[19]

4.1. Introduction

The purpose of the present chapter is to approach efficiency via profits analysis rather than cost efficiency perspective followed in the previous chapter. Färe and Grosskopf (1995 and 1997) proved that both efficiency measures are actually related. In a first stage (Färe and Grosskopf (1995)) the authors demonstrated how to obtain Farrell (1957) efficiency measures from a Mahler inequality which put into relation the cost and input distance functions. In Färe and Grosskopf (1997), they completed the analysis showing how to obtain input and output based decompositions of Farrell efficiency measures, this time using as a starting point a modified definition of Nerlove (1965) profit efficiency measure. Finally, relating the Nerlovian profit efficiency measure with the Mahler inequality, the authors showed the duality profit maximisation - cost minimisation, generalising their previous (1995) paper's result.

The methodology we apply here builds on the works of Lee and Chambers (1986) who developed a model of profit maximisation with a short-run expenditure constraint, and Färe, Grosskopf and Lee (1990) who developed a non-parametric approach for the model of Lee and Chambers (1986). More recently, Blancard, Boussemart, Briec and Kerstens (2003) extended the model of Färe et al. (1990) in terms of directional distance functions and test for the presence of credit constraints in the short-run and investment constraints in the long-run.

[19] This chapter benefited from comments of the participants in the seminar presented at UAB, Business Economics Department, Barcelona, June 2003.

Nevertheless, several aspects mark the difference for the model we apply here. We maximise profits, in a non-parametric setting, and distinguish between unconstrained and constrained profit functions. For this last case we set up additional constraints on debt (credit), interest and fixed assets. The loss in profits due to these constraints indicates that they are binding.

A first difference comes from the fact that Färe et al. (1990) work with expenditure constraints only. Moreover, the constraints are constructed for every unit in terms of its own inputs thus, without affecting the frontier technology. In our case, the constraints are built for every unit in terms of other units' inputs. In this framework our constraints will affect the frontier technology: the fact that they are binding will be reflected by a shift inwards of the profit frontier. In other words, firms were not able i.e. to get more credits in order to reach the optimal profit frontier because of the binding credit constraints.

Second, we link the credit constraints analysis to the literature on soft/hard budget constraints, first introduced by Kornai in the former socialist economies. A binding constraint is an evidence for firms facing hard budget constraints.

Third, like the authors above mentioned, we work with data at firm level, not with agricultural farms, as they do but with firms from manufacturing sector. Fourth, we do not deal only with one region/country (U.S. or France), but put together six manufacturing sectors from seven countries. Fifth, while Lee and Chambers, and Färe et al. work only with expenditure/credit constraints, and Blancard et al. with credit and investment constraints, we consider credit and additional interest and fixed assets constraints.

Finally, in contrast with Blancard et al. our constraints are taken into account not only in the profit maximisation model but also in the determination of the directional technology distance function. This is actually a consequence of the fact that in this setting the constraints may shift the frontier.

Our profit measure is calculated according to the balance sheet approach as the difference between revenue (turnover) and costs (wages, material expenses, depreciation and interest paid). Furthermore, exploiting the duality between the directional distance function and profits, we construct the Nerlovian profit efficiency (NPE) measure in line with the Färe and Grosskopf (1997) paper in a non-parametric framework. Next, we decompose this profit efficiency measure in two components: technical efficiency (TE) and allocative efficiency (AE) but we do not estimate them empirically in this analysis.

The directional technology distance function, by definition allows either for inputs minimisation or output maximisation or both. The answer to the question of which definition is more appropriate, is not trivial. The existing literature does not give a clear-cut answer to this question. In this chapter we apply all three combinations, input-output, input, and output distance functions measures, in a variable returns to scale (VRS) setting.

The literature on *soft/hard budget constraints* applies these concepts mainly within a theoretical framework, analysing their political implications concerning governmental regulations on credit accessibility for the firms. Apart from the theoretical analysis we perform an empirical study of the impact of credit constraints on firms' performance.

We estimate also panel data models for all industrial sectors pooled together, and for each industry separately. The objective is to capture the differences in firms' performance across countries, industries and time, controlling also for the impact of variables like owner-types, size, or return on shareholders funds. All these control variables together help us to better characterise the business environment – i.e. demand shocks, impact of competition, costs related to labour laying off, investment opportunities, etc. – which indirectly affects also firms' productive efficiency. The ownership effect, in particular, is in itself an important motivation of this analysis due especially to the evidence that is gradually accumulating on the contribution of various ownership structures in transition economies to the firm performance[20]. Finally, we apply a *t-test* to check for significant differences between firm performance with and without constraints on the profit functions.

[20] See, for example, Konings et al. (1996) and Earle et al. (2002).

Our results show that the transition economies are on average less efficient than the countries in the advanced market economies. The constraints imposed on the profit functions are binding, and the differences in firms' performance before and after including them are statistically significant, especially in the case of transition countries. There is variation in the performance of the firms across countries and industries, and large firms perform better than the small firms which in our data base represent a relatively reduced percentage.

The chapter is distributed as follows: in the next section we make a short overview of the theoretical background on soft and hard budget constraints. In section 3 we explain the methodology on directional distance functions and profit efficiency measure decomposition. Section 4 is dedicated to the optimisation programmes, section 5 to the empirical results, and in section 6 we conclude.

4.2. Soft and Hard Budget Constraints. Concepts and Evidence.

4.2.1. "Soft Budget Constraint (SBC)"

If one oversees the theoretical works of Walras, Arrow and Debreu one basic idea is that only households or individuals face budget constraints. The first to speak about *enterprise budget constraint* in former socialist economies was Kornai (1979, 1980). Enterprises maximise profits subject to technology constraints. But, to understand their behaviour it is important to know under what circumstances the additional financial constraints are binding or not. Moreover, Kornai argues that this applies not only to firms in socialist economies but also to firms in a market economy and, more generally, to all organisations with monetary income and expenditure.

Speaking about the socialist economy, Kornai own explanation of SBC is based on bureaucratic paternalism. SBC is viewed as a *subsidy* paid, typically by the state, to firms with financial difficulties (loss-making firms) to guarantee their survival[21]. This paternalistic attitude is due to the fact that the state is not willing to accept the social

[21] See also Kornai (1993).

impact (i.e., unemployment) of a failing firm's closure. The notion of SBC is used in practice with different definitions (see below). Consequently the multitude of these SBC's definitions leads to diverse views of whether firms in transition economies face SBCs in the economic literature. The SBC arises when there is a vertical relationship between organisations and agents. In other words, there is a degree of dependency, i.e. a relationship of superiority and subordination and the superior organisation provides financial support to the subordinate one. Kornai's work focuses in particular on the vertical relationship between the government and the enterprise.

Many authors argue that the main difference when consider the SBC in socialist vs. market economies is that in the former case the government acts *ex post* while in the capitalist economies the intervention is made *ex ante* enabling this way firms to survive and avoid bankruptcy. Some authors, on the contrary, consider this distinction as not very convincing given that *ex ante* and *ex post* interventions can be found both in socialist and capitalist economies.

Beyond the *ex ante / ex post* dichotomy Kornai argues that the key point when speaking about the SBC phenomenon is the expectation of the decision-makers as to whether the assistance from the government will be repeated with a certain frequency such that they learn to depend on it. That is to say, state rescues have to be seen as a continuous variable rather than punctual actions. The objective of such interventions is either *ex ante* or *ex post* efficiency (see Dewatripont and Maskin, 1995; Bai and Wang, 1998).

Schaffer (1998) examines also the various definitions of the SBC that are used both from a theoretical and empirical point of view and revisits the most significant papers. Schaffer (1998) stresses the following most commonly used definitions of SBC:

(a) The SBC concept interpreted as an ex post bailout of loss-making firms as a result of the paternalistic preferences of the state is the most common. In their model, Hillman *et al.*(1987) argue that firms are facing an uncertain output price; in particular a low price makes necessary a government bailout in order to avoid unemployment which would be socially costly. In the same fashion Goldfeld and Quandt (1988, 1990), use models to analyse the consequences of the SBCs on factor demand. According to the authors, the amount of the subsidy depends in part on the resources dedicated by the loss-making firms to lobbying. So, SBCs increase factor demand and, hence, contribute to shortage in the socialist economies.

To Gomulka (1985) is due the concept of "budget flexibility". The author argues that apart from being soft the budgets must also be more flexible than prices: sufficient increases in prices can eliminate excess demand and, hence, shortage. Moreover, Gomulka argues that the most important consequence of the SBCs is the inefficiency of firms. Schaffer (1989), demonstrates how the SBCs are the result of the state being "weak" (paternalistic), is to say unable to build a reputation for toughness and not rescue a firm that fails. Boycko *et al.* (1996), expand the concept of SBC concentrating on the "paternalism of politicians" who give priority to employment-supporting subsidies and not only to bailouts.

(b) There are other uses of the SBC concept in the economic literature but they differ from the above definition. For example, Stiglitz (1994, p. 184) referring to the U.S. experience argues that SBCs also arise when institutions "have an incentive to make large gambles". This example extends the application of SBC concept to the case of the insolvent banks who try to bailout their insolvency by making risky loans. The idea is that of financing an *ex ante* risky project: if the payoff is high then the bank will become solvent while if the project's payoff is low then the bank will not be worse off than before.

(c) Another extension refers to the SBC concept emerging from an adverse selection model. Dewatripont and Maskin (1995), Qian (1994), Berglöf and Roland (1997), and others analyse the case of a bank (creditor) funding in the first-period a project whose outcome is uncertain. *Ex post* the first-period the bank will learn that the project was bad, but if the prospects for the project in the second-period are good enough the bank will continue funding the project. This decision is supported by the fact that the loss in the first-period is a sunk cost and refunding the project in the second-period means a greater return to the bank than if the bank terminates the project after the first-period. So, the decision of the bank to continue financing a project which after the first-period proves to have been bad, is an example for the existence of SBCs.

4.2.2. From Soft to Hard Budget Constraint Regime

In our analysis we combine in the data set both firms in transition and market economies. Nevertheless, the approach of the concepts of SBC/HBC when analysing firms acting under the market discipline is also based on the seminal work of Kornai. Most of the empirical studies on market economies analyse the impact of SBC/HBC on the performance of public firms. The performance of the public sector is considered as unsatisfactory not only in transition countries but also in these countries. Authors like Laffont and Tirole (1993) and Shleifer and Vishny (1994) pointed out in their studies the absence of a HBC and the lack of a more severe financial discipline.

Bertero and Rondi (2000), study the effect of the hardening of budget constraints on the behaviour of state-owned Italian manufacturing firms in the late 80s. They investigate in particular the financial discipline enforced by debt. Their findings show that state firms do respond to financial pressure by increasing productivity and reducing labour costs via labour shedding in a HBC environment.

We approach here the concepts of SBC/HBC in a similar fashion, that is from a financial perspective. We are interested to quantify the impact of financial pressure (credit constraints) on firms performance in profit efficiency.

One limitation of this approach is that since profit can be defined in different ways, the conclusions drawn from the analysis of profit / loss and balance sheet data has to be interpreted with care. Only to provide some examples, it could be that a firm may be currently making losses but be expected to make large profits in the future, or it could be the case that the firm is economically viable but loss-making because it has a large debt burden.

Another problem relates to the presence of overdue debts on firms' balance sheets, in the form of tax arrears, which is very common for the transition economies. The presence of stocks of overdue debts it is not necessarily a conclusive evidence of financial distress or SBCs. According to Schaffer (1998), it is necessary to distinguish between stocks and flows[22]. The evidence shows that in transition economies firms usually apply hard budget constraints to each other: in other words, enterprise arrears have not been the typical source of SBCs.

Finally, a low number of bankruptcies it is not always evidence of SBCs. In transition economies this is rather the consequence of an inadequate legal framework and the lack of experience with bankruptcy laws. In these countries in particular, the bank – enterprise relationship is quite complex and usually the bank system is the route via which the budget constraints are softened. Schaffer (1998) mentions the so-called state direct credits used by governments to bailout loss-makers as providing firms with SBCs.

Moreover, the author argues that if consider the case of bank loans (except the state credits), the evidence on SBCs it is not so clear. It is necessary to look for evidence that loss-making firms are receiving net bank financing (NBF), that is nominal bank debt less interest due. According to this measure, if NBF is positive this means that the bank is providing a loss-making firm with a SBC. A negative NBF, on the contrary would imply that the bank is imposing a HBC to the distressed firm. The evidence for some transition economies shows that tax arrears seem to be the way by which firms are provided with SBCs (i.e. if the tax authority tolerates distressed firms not to pay their tax, and this seems to be the case, this is an ex post subsidy that saves the loss-making firms and a clear case of SBC).

Summarising, Schaffer (1998) recommends that when looking for evidence on SBCs in transition economies the following steps should be followed: establish first the nature of the losses generated by firms and determine the presence of economic or financial distress

[22] In Alfandari and Schaffer (1996), the authors discuss in detail in which conditions stocks of arrears can accumulate.

or neither, and second see whether the distressed firms receive net financing, either as subsidies or in the form of lending and increases in debt over and above accrued interest costs.

Coricelli and Djankov (2001) study the case of Romanian public enterprises during the early transition period (1992-1995), identify the presence of SBCs, and analyse their impact on enterprise performance. They define SBCs as repeated bail-outs or continued financing of the distressed enterprises and identify, the passive restructuring (i.e. reduction in excess labour) as being a consequence of a hardening of budget constraints. Further on, they found evidence that one of the effects of HBCs is the lack of active restructuring in the form of new fixed investment. The numbers show also that bank loans and tax arrears were the main factors favouring the SBCs.

Claessens and Djankov (2002) analysed manufacturing enterprises in several transition economies, including Bulgaria and Romania, during the period 1992-1995 and found evidence that reductions in soft financing were associated with further productivity gains.

In Appendix 4.1. we calculate the average number of employees for every country and industry sector along the period 1995-1998. Independent of the sector analysed there is one important aspect which deserves to be pointed out: in the two transition economies, Bulgaria and Romania, there is a substantial decrease in the average number of employees from 1995 to 1996. For the market economies the general tendency is rather one of a certain stability and, in some countries one observes even an increase in the average number of employees. In other words, we could say that the labour shedding effect is much stronger in transition economies. In Table 1 we present the results corresponding to sector 252 – manufacturing of plastic products – which apart from being the largest in the sample, reflects very well the behaviour typical for the rest of the sectors.

Table 1: Labour average - Sector 252 - Manufacturing of Plastic Products

Country	**1995**	**1996**	**1997**	**1998**
Belgium	127	127	130	135
Bulgaria	609	597	562	517
France	278	281	280	302
Italy	154	175	184	175
Netherlands	1260	1326	1295	1576
Romania	949	928	865	745
Spain	237	244	243	255

In this analysis we work with firms' profits and we calculate them as earnings after the firm covers the basic operating costs of its activity (i.e., labour and material costs) and after interest and depreciation. According to this definition, losses or negative profits may indicate either economic distress (i.e., the firm is not able to cover the basic costs associated with its activity) or financial distress. The SBC analysis applied here is more about firms in financial distress. Depending on whether the presence of the debt burden (credit) constraint affects or not the firm's efficiency, we speak about (i) SBC when the credit constraint is not binding, and (ii) HBC if the credit constraint is binding. The way we measure this is looking at the firms' profit efficiency performance with and without credit constraint.

4.3. Profit Maximisation and Directional Distance Functions

4.3.1. Nerlove's Profit Efficiency Measure

The traditional approach of the efficiency-measurement literature is mostly based on input and output distance functions. This *modus operandi* follows the works of Debreu (1951) and Farrell (1957), who defined measures for the technical efficiency based on the inverse of these functions.

Nerlove (1965) proposed an alternative efficiency measure based on profit. The methodology proposed by the author consists in maximising the profit in two steps: a) maximise profit for a given production function; b) find the maximum maximorum of profit maximising over all production functions. Then compare the observed profit for an observation unit to the maximum maximorum profit and determine this way overall efficiency. Following Farrell (1957), this profit efficiency measure which for the rest of the present chapter is refered to as Nerlovian profit efficiency (NPE) is then decomposed in two components: (price or) allocative efficiency (AE) and technical efficiency (TE). TE compares the observed profit to the profit function for the given production function while AE measures the difference between the profit function for the given production function and the maximum maximorum profit[23].

In the present chapter we revisit Nerlove's profit efficiency measure but in a framework that allows us to work with multiple inputs and outputs and use a representation of technology based on directional technology distance function. Moreover, we work in a non-parametric setting assuming variable returns to scale (VRS), and analyse profit maximisation and profit efficiency measure considering the effects of additional constraints like interest, credit and fixed assets. The main objective is to observe the impact on firms' profit efficiency performance and further on to relate this with the literature on SBCs / HBCs.

4.3.2. Directional Distance Functions

The radial distance functions defined by Shephard (1970) measure the largest radial improvements (input vector reduction / output vector increase) that are technically feasible. The directional distance function measures the amount that an input and / or output vector can radially be translated from itself to the technology frontier in a given direction. This direction may differ from Shephard's radial direction towards the origin, thus making the directional distance function more general.

Let us represent the technology T as given by

$$T = \{(x, y) : x \text{ can produce } y\} \tag{1}$$

[23] See Chambers, Chung and Färe (1998) for a more detailed explanation.

where $x = (x_1,...,x_N) \in \Re_+^N$ represent the inputs vector and $y = (y_1,..., y_M) \in \Re_+^M$ represent the outputs vector. We assume all standard assumptions on this technology as satisfied.[24] While Shephard's input distance function is defined by scaling inputs, and the output distance function by scaling outputs, the directional distance function in its most general form can be defined by scaling both inputs and outputs simultaneously:

$$D_T(x, y, g_x, g_y) = \sup\{\beta : (x - \beta g_x, y + \beta g_y) \in T\} \tag{2}$$

where $g = (g_x, g_y)$ is a nonzero vector that determines the direction in which the directional distance function is defined, to the boundary of *T*. Because βg_x is subtracted from *x,* the direction in fact is $(-g_x, g_y)$ and thus, the function is defined by the simultaneous contraction in inputs and expansion in outputs. The distance can be interpreted as an efficiency measure, i.e., by how much output can be expanded and input contracted consistent with feasibility. We can see that if $(x, y) \in T$, then $\vec{D}_T(x, y; g_x, g_y) \geq 0$.

The technology *T* can then be recovered from the directional distance function as

$$T = \{(x, y) : \vec{D}_T(x, y; g_x, g_y) \geq 0\} \tag{3}$$

Two special cases of $D_T(x, y; g_x, g_y)$ are of interest here:

First, if $g_y = 0,$ then:

$$\vec{D}_T(x, y; g_x, 0) = \vec{D}_i(y, x; g_x), \tag{4}$$

where $\vec{D}_i(y, x; g_x)$ is the input directional distance function defined by Chambers, Chung and Färe (1996). Furthermore, if $g_x = x,$ then we obtain a relation between the directional technology distance function and Shepard's traditional input distance function:

[24] See Färe (1988) for a complete description and proof of these assumptions.

$$\vec{D}_T(x, y; g_x, 0) = 1 - 1/D_i(y, x) \tag{4.1}$$

By choosing $g_x = 0,$ we can derive the output directional distance function

$$\vec{D}_T(x, y; 0, g_y) = \vec{D}_o(x, y; g_y), \tag{5}$$

and if $g_y = y,$ in the same fashion we can link the directional technology distance function with Shepard's output distance function, namely,

$$\vec{D}_T(x, y; 0, g_y) = (1/D_o(x, y)) - 1 \tag{5.1}$$

From expressions (4) - (5.1) it can be seen that the directional technology distance function is in fact a complete generalisation of Shepard's distance functions. Graphically, if we assume that we use one input *x* to produce one output *y*, then $\vec{D}_T(\cdot)$ is illustrated in Fig.1 where $g = (-g_x, g_y)$ is the directional vector. The input-output vector (*x, y*) is projected onto the technology *T* at $(x', y') = (x - \vec{D}g_x, y + \vec{D}g_y)$.

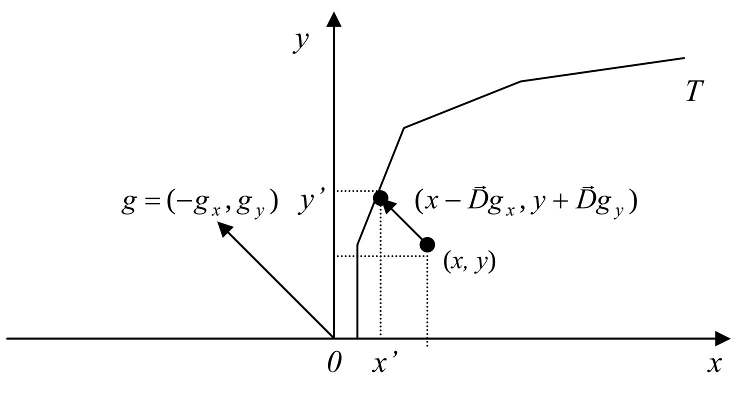


Figure 1. The directional technology distance function

Furthermore, consider a vector of output prices $p = (p_1,..., p_M) \in \Re_+^M$ and a vector of input prices $w = (w_1,..., w_N) \in \Re_+^N$. The profit function is then defined as

$$\pi(p,w) = \sup_{(x,y)\geq 0} \{py - wx : (x,y) \in T\} \qquad (6)$$

This function gives the maximal feasible profit given prices (*p, w*) and technology, and can also be written in terms of the directional distance function as follows:

$$\pi(p,w) = \sup_{(x,y)\geq 0} \{py - wx : \vec{D}_T(x,y;g_x,g_y) \geq 0\} \qquad (7)$$

The duality between profits and directional distance function is proven in Luenberger (1992) and exploited in Chambers et al. (1996) and Chambers et al. (1998). It allows to write the constrained optimisation problem (7) as an unconstrained problem:

$$\pi(p,w) = \sup_{(x,y)\geq 0} \{py - wx + \vec{D}_T(x,y;g_x,g_y)(pg_y + wg_x)\} \qquad (8)$$

In Fig.2 one can see the graphical representation of expression (8), where point (*x*, y**) gives the input – output combination that is maximizing profits. Point (*x*, y**) is a tangency point between the technology *T* and the normalised input price line. As shown in Chambers et al. (1998) any translation of point (*x*, y**) in the direction of $(-g_x, g_y)$ is a solution to expression (8). For this point, the directional distance function yields:

$$\vec{D}_T(x^*, y^*; g_x, g_y) = 0 \qquad (9)$$

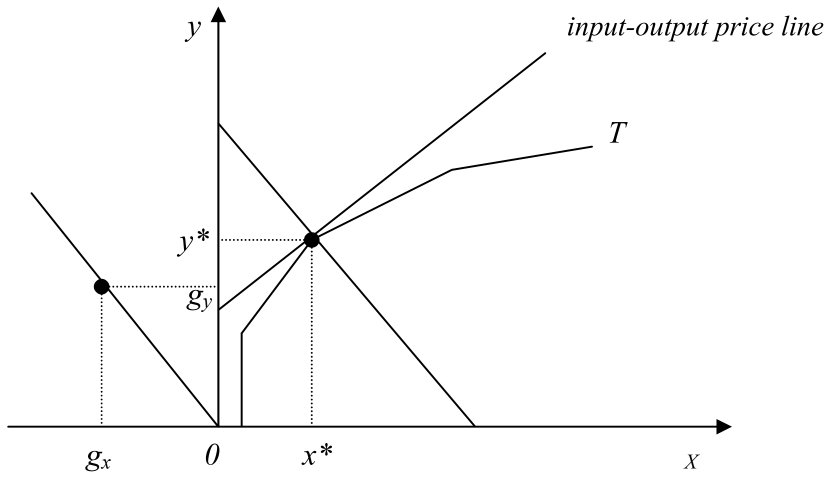


Figure 2. Profit maximisation

In fact, following the proof in Chambers et al (1998)[25], expression (8) can be obtained from a more general inequality:

$$\pi(p,w) \geq py - wx + \vec{D}_T(x,y;g_x,g_y)(pg_y + wg_x) \quad (10)$$

If one rearranges the expression (10), then the duality between the convex technology *T* and the profit function can be expressed as follows:

$$\vec{D}_T(x,y;g_x,g_y) = \inf_{(p,w)\geq 0}\left\{\frac{[\pi(p,w)-(py-wx)]}{(pg_y + wg_x)}\right\} \quad (11)$$

The right-hand side of expression (11) represents the normalised profit function and is refered to as Nerlovian profit efficiency (NPE). In fact, this is the normalised deviation between maximal and observed profit $[\pi(p,w)-(py-wx)]$, the normalisation being the value

[25] In Chambers et al. (1998), in Appendix (Section 6) the authors present the proof of the optimisation problem (8).

of the direction $(pg_y + wg_x)$. The normalisation implies that profit efficiency is homogeneous of degree 0 in prices. The left-hand side of expression (11) represents the directional distance function measure of technical efficiency.

Following Chambers et al. (1998), in Fig. 3 we give the graphical representation of a normalised profit function, as a function of the normalised output price vector. Choosing the point which minimises the vertical distance between the profit function and any line with slope *x/y* we can see the normalised profit function given in expression (11).

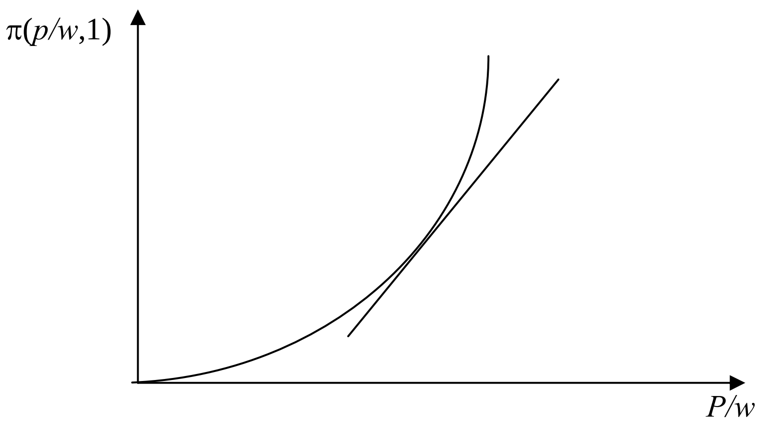


Figure 3. Profit – technology duality

4.3.3. Nerlovian Profit Efficiency Measurement and Decomposition

In accordance with the optimisation problem (11) our profit efficiency measure is

$$NPE = \frac{[\pi(p,w)-(py-wx)]}{(pg_y + wg_x)} \qquad (12)$$

and technical efficiency, as mentioned above is measured by the directional distance function which provides a direct measure of how far (x,y) must be projected along

(g_x, g_y) to reach the boundary of the technology *T*. This can be taken in fact as a measure of inefficiency.

$$TE = \vec{D}_T(x, y; g_x, g_y) \tag{13}$$

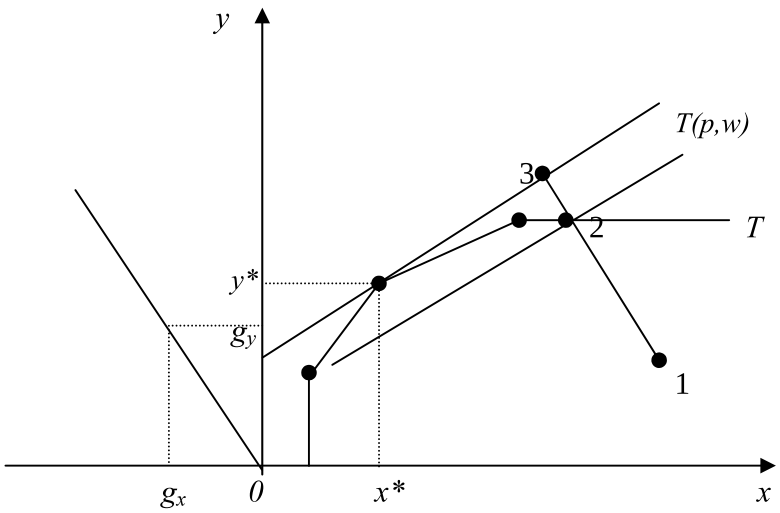
For both expressions (12) and (13) the direction (g_x, g_y) can be chosen as the realised input-output vector (*x, y*), in which case we do not need to initially pre-assign any direction. Allocative efficiency is defined here as the difference transforming inequality (10) into an equality:

$$AE = \frac{[\pi(p,w)-(py-wx)]}{(pg_y + wg_x)} - \vec{D}_T(x, y; g_x, g_y) \tag{14}$$

Combining the last three expressions we yield the following decomposition of profit efficiency:

$$NPE = AE + TE \tag{15}$$

Several important aspects need to be pointed out here: first, while Nerlove's measures for allocative and technical efficiency are expressed in ratio form, we present them here in difference form; second, *NPE* is always nonnegative, given any feasible input-output combination; third, this nonnegativity also extends to the *TE* and *AE* measures. This means that any feasible input-output combination that is Nerlovian efficient must also be both technically and allocatively efficient. The complete interpretation of the efficiency measures expressed above, in terms of the directional distance function can be seen in Fig. 4. We show this for the input-output vector (*x, y*) given in the graph by point 1. As it can be noticed, *AE* is the difference between *T*(*p, w*), the outer approximation of *T*, and *T*.



NPE = (3-1); TE = (2-1); AE = (3-2)

Figure 4. Profit efficiency measures in terms of directional distance function.

In this analysis, as mentioned in a previous section, we calculate the profit- based efficiency measures working with the three orientations for the distance vector $g = (g_x, g_y)$: input-output orientations, expressions (12-14), input $(g_y = 0, g_x = x)$ and output $(g_y = y, g_x = 0)$ orientation. For the input- based case, expression (12-14) becomes

$$NPE = \frac{[\pi(p,w) - (py - wx)]}{wx} \quad (12.1)$$

$$TE = \vec{D}_i(x, y; x, 0) \quad (13.1)$$

$$AE = \frac{[\pi(p,w) - (py - wx)]}{wx} - \vec{D}_i(x, y; x, 0) \quad (14.1)$$

and for the output- based case we finally have the following:

$$NPE = \frac{[\pi(p,w) - (py - wx)]}{py} \quad (12.2)$$

$$TE = \vec{D}_o(x, y; 0, y) \tag{13.2}$$

$$AE = \frac{[\pi(p,w) - (py - wx)]}{py} - \vec{D}_o(x, y; 0, y) \tag{14.2}$$

4.4. The Non-Parametric Optimisation Programes

The calculus of the profit-based efficiency measures presented in the previous section is developed in a non-parametric framework with variable returns to scale technology, and considering the input and or output orientation for the directional distance function. We construct a deterministic profit function using a programming approach, with and without credit constraint, interest and fixed assets constraints and obtain individual evaluations on performance and the constraints above mentioned.

4.4.1. Profit Function Maximisation and Directional Distance Function Programes

We recall the input $x^k = (x_1^k,...,x_N^k) \in \Re_+^N$ and output $y^k = (y_1^k,...,y_M^k) \in \Re_+^M$ vectors defined in section 4.3.2., as well as the price vectors for output $p \in \Re_+^M$, and input $w \in \Re_+^N$ vectors. All firms are assumed to face the same input and output prices for each input and output, therefore the *k* superscript is dropped from these price vectors. *k = 1,…, K* represent the number of observations for inputs and outputs, and these observations may be for the same firm over *K* periods or *K* firms in the same period of the panel. Then the linear programming problem that maximises profit for the firm *k* is the following:

$$\pi(p, w) = \max_{y_i, x_j, z} \sum_{i=1}^{M} p_i y_i - \sum_{j=1}^{N} w_j x_j \tag{16}$$

$$s.t.$$
$$z \cdot Y \geq y$$
$$z \cdot X \leq x$$
$$\vec{1} \cdot z = 1$$

where $z = (z^1,...,z^k,...,z^K)$ is the intensity vector. The definition of this variable in programme (15) indicates a variable returns to scale setting. We do not distinguish between fixed and variable inputs.

For each firm *k*, the directional distance function with input-output orientation, can be estimated with the following linear programming problem:

$$\vec{D}_T(x^k, y^k; -x^k, y^k) = \underset{\beta \geq 0}{Max}\, \beta^k \qquad (17)$$
$$s.t.$$
$$(1+\beta^k)\cdot y^k \leq z \cdot Y$$
$$(1-\beta^k)\cdot x^k \geq z \cdot X$$
$$\vec{1}\cdot z = 1$$

If $\beta = 0$, then it is not possible to simultaneously contract inputs and expand output, whereas this situation is possible if $\beta > 0$. The input and output directional distance functions are variations of the problem (16) and can be determined by solving the following linear programming problems:

a) Input directional distance function

$$\vec{D}_T(x^k, y^k; -x^k, 0) = \underset{\beta \geq 0}{Max}\, \beta^k \qquad (17.1)$$
$$s.t.$$
$$z \cdot Y \leq y^k$$
$$(1-\beta^k)\cdot x^k \geq z \cdot X$$
$$\vec{1}\cdot z = 1$$

b) Output directional distance function

$$\vec{D}_T(x^k, y^k; 0, y^k) = \underset{\beta \geq 0}{Max}\, \beta^k \tag{17.2}$$
$$s.t.$$
$$(1+\beta^k)\cdot y^k \leq z \cdot Y$$
$$x^k \geq z \cdot X$$
$$\vec{1} \cdot z = 1$$

4.4.2. Constrained Profit Functions and Directional Distance Functions: The Non-Parametric Models.

We have for each firm *k* information on its financial debt (credit), interests paid and fixed assets. Let credit be denoted as *D*, interest as *I* and fixed assets as *A*. Then the corresponding constraints for firm *k* can be written as:

a) Credit constraint

$$z^1 D_1^k + z^2 D_2^k + ... + z^k D_l^k \leq D^{ok} \tag{18}$$

where D^{ok} is the observed debt of the firm *k*. In this case, as we perform the analysis year by year, we consider that the firms are facing a given debt (credit) constraint which cannot be varied during the year. In this framework, we allow for a different interpretation of *credit constraint* concept. Färe, Grosskopf and Lee (1990) set up expenditure constraints in terms of each firm's *own* inputs only, hence their expenditure constraint does not affect technology.

Graphically, in Fig. 5 the expenditure constraint is illustrated by the area between the vertical line *DD'* and the output axis. If one takes as reference the point (1) where profit (π) is maximised, situation (a) corresponds to a binding expenditure constraint because the maximum profit that can be obtained by the firm is (2), while situation (b), point (3), shows a non binding constraint given that we can always adjust to a point like (1).

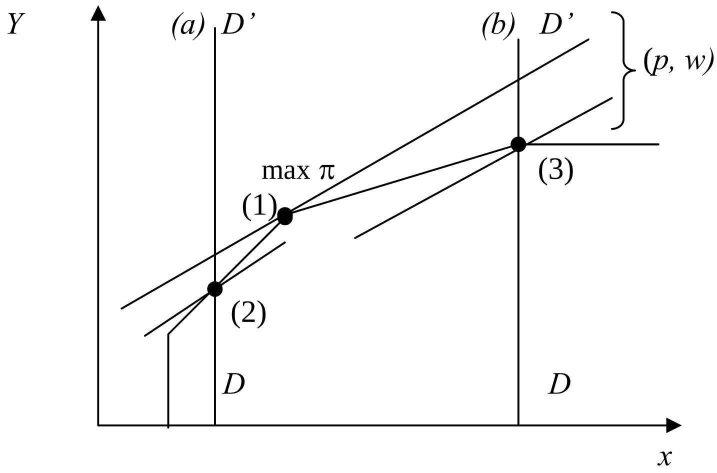


Figure 5. Expenditure – constrained profit maximisation

The fact that a point like (2) is not maximising profits could be explained by the firm facing credit constraints or negotiation problems with the bank. A point like (3) instead could reflect bad financial management given that the firm could always choose to spend less.

In expression (18) what we do instead is to relate a firm credit (debt) constraint to other firms' credit (debt) situation. In other words, we set up the credit constraint of a firm in terms of other firms inputs (credit). We take account for the similarity in debts across firms in all countries, and this way the constraint is affecting the technology. The absence of slacks in expression (18) indicates that the credit constraint is binding (HBC).

Graphically, the fact that the credit constraint is binding could be explained with the help of Figure 6. The frontier with credit constraint i.e., $\pi(p,w,D)$ is shifting inwards getting closer to the observed unit B (x^o,y^o). This indicates that the credit constraint is binding. The firm is facing hard budget constraints, can reach only a point like (b), and was not able to get more credit in order to reach the initial frontier $\pi(p,w)$, point (a).

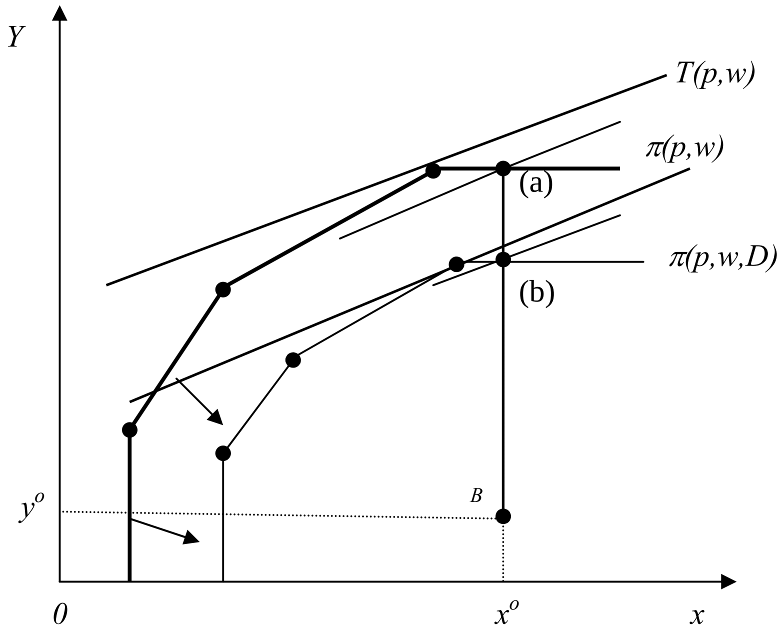


Figure 6. Profit maximisation with binding credit constraint

The reasoning is the same for the interest and fixed assets constraints.

b) Interest constraint

$$z^1 I_1^k + z^2 I_2^k + ... + z^k I_l^k \leq I^{ok} \tag{19}$$

where I^{ok} is the observed interest paid by firm *k*.

c) Fixed assets constraint

$$z^1 A_1^k + z^2 A_2^k + ... + z^k A_l^k \leq A^{ok} \tag{20}$$

and A^{ok} represent observed level of fixed assets for firm *k*. Fixed assets constraint involves both internal and external financing while the interest constraint is only external. Hence, we would expect fixed assets constraint to be less binding than the interest constraint.

Following the notation in section 4.4.1. the linear programming problems that maximises profit and calculates the directional distance function for firm *k* with *credit constraint* are (21.a) and (21.b):

$$\pi(p,w) = \max_{y_i, x_j, z} \sum_{i=1}^{M} p_i y_i - \sum_{j=1}^{N} w_j x_j \tag{21.a}$$

$$\begin{aligned} & s.t. \\ & z \cdot Y \geq y \\ & z \cdot D \leq D^o \\ & z \cdot X \leq x \\ & \vec{1} \cdot z = 1 \end{aligned}$$

$$\vec{D}_T(x^k, y^k; -x^k, y^k) = \underset{\beta \geq 0}{Max}\, \beta^k \tag{21.b}$$

$$\begin{aligned} & s.t. \\ & (1+\beta) y \leq z \cdot Y \\ & (1-\beta) x \geq z \cdot X \\ & z \cdot D \leq D^o \\ & \vec{1} \cdot z = 1 \end{aligned}$$

The problems for the input and output credit constrained directional distance functions are similar to (17.1) and (17.2) the only difference being that now the credit constraint as defined in (21.b) is included.

In the same fashion the programmes for interest and fixed assets constrained profit and directional distance function are similar to problems (21.a) and (21.b), except for the credit constraint being replaced now by the constraints (19) and (20) respectively.

4.5. Empirical Results

We first report the Nerlovian profit efficiency results with and without constrained profit functions and discuss our findings. The profit efficiency scores we calculate are: Nerlovian profit efficiency (NPE), Nerlovian profit efficiency with credit constraint (NPE-

CC), with interest constraint (NPE-I), and with fixed assets constraint (NPE-FA). We do not report empirical results for technical and allocative efficiency, TE and AE, respectively. This is due to the fact that we are particularly interested in the measurement of profit efficiency overall, and in testing the impact of the constraints imposed.

Then, the profit efficiency scores, in VRS and input-output orientation of all six sectors, seven countries and four years are pooled together and used as dependent variables in regression analysis. The linear mixed effects (LME) model is used in order to quantify fixed and random effects. We perform also a *t*-test, for every sector and country, when comparing paired efficiency scores (NPE & NPE-CC, NPE & NPE-I, NPE & NPE-FA).

4.5.1. NPE Estimates and Decomposition

We calculate the profit efficiency scores in a variable returns to scale setting considering the three possibilities: input-output, input and output orientation. The variables we worked with are presented in Table 2 below:

Table 2: Financial Variables

Profit = Revenue – Cost	Revenue =	Turnover
	Cost =	Cost of Employees Material Expenses Depreciation Interest Paid
Credit Constraint	Total Liabilities (short and long-run)	
Fixed Assets Constraint	Fixed Assets	
Interest Constraint	Interest Paid	

Our findings support the conclusion that on average all constraints - credit, interest and fixed assets – are binding, not only at sector level but also for each country in each sector, and this is true for all time period, 1995 – 1998. If we were to rank the three constraints we may say that in two sectors, 172 and 251, the most binding is the credit constraint, followed by the fixed assets and finally the interest constraint. In the other four sectors, 175, 211, 241, and 252, the fixed assets and interest constraints interchange places, and interest constraint goes in front of fixed assets constraints.

When presenting the results, for each country, we distinguish between firms with positive profits and firms with losses. We also give some basic statistics but only for the sample of firms exhibiting positive profits (+). From the data we could see that the constraints are particularly binding for the loss making firms. In Table 3 hereafter we present a piece of results for the NPE, NPE-CC, NPE-I, and NPE-FA with input-output distance functions. The complete results for all sectors (Input-Output, Input and Output orientation), and all years are presented in Appendix 4.3. at the end of the chapter.

Several aspects has to be considered in the interpretation of the results. First, we group them taking as criterion the direction of the normalisation: input-output, input or output. The reason is that as defined in relation (11) our Nerlovian profit efficiency (NPE) measure is a normalised deviation between maximal and observed profits, and in this way we can compare the changes observed in profit efficiency when adding more constraints (i.e., for input-output orientation, the denominator is the same). Second, the definition of the profit efficiency measure in itself, explains why in some cases big numbers may appear. The NPE measure is in fact an indicator of profit inefficiency. The greater the NPE, the greater the inefficiency of the firms. In this setting for a profit efficient firm NPE value would be zero.

Table 3: Sector 172 – Profit Efficiency

1995	**Input – Output Orientation**			
	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	10.0637	3.5634	0.7048	1.2423
Belgium (+20)	1.8974	1.5562	0.3159	0.6966
Bulgaria (+7)	8.5068	5.2874	0.8230	1.7898
(-1)	6.3421	3.6341	1.2822	1.9789
France (+25)	1.4770	0.7584	0.2321	0.4467
Italy (+55)	1.8851	1.4280	0.4665	0.5179
(- 2)	11.8792	7.6047	3.6138	5.8453
Romania (+43)	30.9508	8.8247	1.4602	2.8750
(-5)	31.4604	13.6662	2.6216	5.4083
Spain (+10)	4.1208	2.5055	0.6442	0.9035
Max.Value (+)	289.939	44.9897	4.8640	9.6791
Min.Value (+)	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	33.5595	5.9470	0.7463	1.5884
Total Units	168	168	168	168

4.5.2. "T – Test" Paired Samples Results

The NPE scores with and without constrained profit functions allow us to draw one important conclusion, that the credit, interest and fixed assets constraints are binding. In order to give even more substance to this result, already supported by the results fully presented in Appendix 4.3., and to put in evidence eventual differences among countries when consider the magnitude of the impact of the binding constraints, we also perform also a *t-test,* analysis comparing the following variables:

- NPE and NPE-CC;
- NPE and NPE-I;
- NPE and NPE-FA.

The *t-test* was performed for every sector and within the sector for every country. From Table 4, presenting the results for sector 172, it can be seen that for all countries the differences between the paired variables analysed are significant. Another conclusion is that the lower/upper bounds are in magnitude much greater for Bulgaria and Romania. In other words, for these two countries in particular, the constraints are much more binding than in the rest of the countries in the sample.

Table 4: T – test Results for Sector 172

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPE-CC	0.3016	0.7216	<0.001
	Pair 2 NPE – NPE-I	1.6137	2.2940	<0.001
	Pair 3 NPE – NPE-FA	1.2689	1.8706	<0.001
Bulgaria	Pair 1 NPE – NPE-CC	108.9556	286.5606	<0.001
	Pair 2 NPE – NPE-I	129.0447	327.4763	<0.001
	Pair 3 NPE – NPE-FA	125.0271	319.0397	<0.001
France	Pair 1 NPE – NPE-CC	0.6536	2.3235	<0.001
	Pair 2 NPE – NPE-I	1.1226	3.3062	<0.001
	Pair 3 NPE – NPE-FA	0.9528	2.9762	<0.001
Italy	Pair 1 NPE – NPE-CC	0.3974	0.6267	<0.001
	Pair 2 NPE – NPE-I	1.7144	2.0798	<0.001
	Pair 3 NPE – NPE-FA	1.6420	1.9560	<0.001
Romania	Pair 1 NPE – NPE-CC	56.5977	92.3230	<0.001
	Pair 2 NPE – NPE-I	69.3074	109.9801	<0.001
	Pair 3 NPE – NPE-FA	66.4964	105.9012	<0.001
Spain	Pair 1 NPE – NPE-CC	1.4857	2.4872	<0.001
	Pair 2 NPE – NPE-I	3.7975	4.9401	<0.001
	Pair 3 NPE – NPE-FA	3.5201	4.5786	<0.001

If consider the case of the credit constraint, the results go in the same line with the literature studying the credit market in the East European countries arguing that the financial markets in these transition market economies are still not enough developed and do not function as well as in the advanced market economies. Similar conclusions are valid for the rest of the sectors. The result are presented in Appendix 4.2. (A) at the end of the chapter.

4.5.3.Framework of the Econometric Estimation

Our objective is to investigate the determinants of constrained and unconstrained NPE estimates. Using a model for panel data in which *i* indexes firms and *t* indexes years, we estimate equations of the form

$$Y_{it} = \beta_0 + \sum_{l=1}^{7} \beta_l country_{it} + \sum_{l=1}^{3} \beta_{8+l} ownership_{lit} + \sum_{l=1}^{6} \beta_{12+l} sector_{lit} + \beta_{19} size_{it} + \beta_{20} Rsh_{it} + \varepsilon_{it} \quad (22)$$

where:

- $l = 1,...,7$ stands for countries
- *country* represents dummies for countries
- $l = 1,...,3$ are the ownership forms (public, private, other)
- *ownership* stands for dummies for the ownership forms
- $l = 1,...,6$ are industry sectors and *sector* represents the dummies for sectors
- *size* = the number of employees
- *Rsh* = the return on shareholders funds (%) and
- ε_{it} is a residual

and random effects: $w_{it} = \beta_0 + v_{it}$

We assume further that:

$E[\varepsilon_{it}] = 0$ *for all i and t*,
$Var[\varepsilon_{it}] = \sigma_{\varepsilon}^2$,
$Cov[\varepsilon_{it}\varepsilon_{mn}] = 0$ *if* $i \neq m$ *or* $t \neq n$,

$E[v_{it}] = 0$ *for all i and t,*
$Var[v_{it}] = \sigma_w^2,$

$Cov[v_{it} v_{ls}] = 0$ *if* $i \neq l$ *or* $t \neq s$*,*
$Cov[\varepsilon_{it} v_{it}] = 0$ *for all i and t*

Y_{it} stands for the measures of firm performance we work with in this analysis: NPE, NPE-CC, NPE-I, and NPE-FA. The specification of our dependent variable, as a normalised difference between maximal and observed firm's profit, serves in fact to neutralise any firm-specific characteristics, such as better technology or larger initial capital stock, that could affect the level of profit (in)efficiency.

We are interested to measure the heterogeneity in performance, Y_{it}, among countries and sectors, and also the influence of return on shareholders funds, owner-types, and size. For this purpose we include: country and industry effects, specifying 7 categories for countries and 6 for the industrial sectors; the size is measured by the number of employees; the return on shareholders funds is given by the ratio profit/loss before tax/shareholders funds x 100; and 3 categories for the ownership types, corresponding to: public firms (S.A.), private (Ltd.), and other type. Initially, we also considered the influence of the degree of capacity utilisation (CU), calculated in the previous chapter. The sign of the variable resulted to be the expected one, negative, indicating that the higher the CU the lower the profit inefficiency of the firms. Nevertheless, we finally preferred not to include CU in the final model given that in almost all cases CU was not found statistically significant.

Another aspect to be considered refers to the business environment conditions faced by the firms in each country which might differ substantially among countries in transition and developed market economies. In other words, the firms acting in a favourable business environment are in better conditions to face and adapt to the impact of competition.

The firms in transition economies are more likely to face greater difficulties in adjusting to the demand shocks, and as a consequence of this the problems of maintaining productivity (i.e. costs of labour shading, obsolete equipment, etc.) are greater. For this reason we included country and industry effects, assuming that these may be correlated with unobserved shocks to a firm's performance, and more of that country effect may reflect as well the market environment in which the firm is acting. Considering all these specifications for the dependent and control variables, the results obtained after estimating Eq. (22) are presented in Appendix 4.2. part (B), at the end of the chapter.

In Table 5, we give the estimates for the case were the dependent variable is the NPE (unconstrained profit function).

Table 5: Panel Data LME model. Dependent variable: NPE

Model	Value	Std. Error	t-value	p-value
Intercept	-66.4814	21.0440	-3.1591	0.0016
Country (Belgium)				
Bulgaria	**967.5620**	**38.1553**	**25.3585**	**<.0001**
France	-17.5938	20.3304	-0.8653	0.3869
Italy	-17.6304	18.5703	-0.9493	0.3425
Netherlands	17.3080	40.8485	0.4237	0.6718
Romania	**270.2539**	**20.1561**	**13.4080**	**<.0001**
Spain	1.1771	22.5315	0.0522	0.9583
Size	**-0.0314**	**0.0039**	**-7.9661**	**<.0.001**
Rsh	-0.0900	0.1334	-0.6745	0.5000
Ownership (Public)				
Private	**66.6304**	**18.5192**	**3.5978**	**0.0003**
Other Type	41.2971	27.2216	1.5170	0.1293
Sector (172)				
175	**76.6001**	**21.1670**	**3.6188**	**0.0003**
211	52.5757	21.9668	2.3934	0.0167
241	**123.5260**	**18.8338**	**6.5587**	**<.0001**
251	**156.5639**	**22.3270**	**7.0123**	**<.0001**
252	**89.0109**	**17.4309**	**5.1064**	**<.0001**

Bold: p<0.05

As it can be seen the two East European countries, Bulgaria and Romania, behave significantly different with respect to Belgium (the reference country) and the rest of the countries. The values of the coefficients for the two countries are extremely large and positive. Taking into account that the NPE scores are calculated as a normalised difference between the maximal and the observed profits, then NPE is in fact a measure of inefficiency. So, the bigger the coefficients, less efficient are the countries. If look at France (-17.5) and Italy (-17.6), the values are rather small and negative which means that they actually are more efficient than Belgium.

The *size* is another significant explanatory variable: for every employee, the NPE coefficient diminishes with about 3%. Again, keeping in mind that NPE is a measure of inefficiency, the size tells us that the larger the firm the smaller the inefficiency. In other words, large firms are more efficient – are closer to the frontier - than the small firms. This conclusion is supported also by the value of the *private* ownership variable. Private firms, which in our database are the small firms, behave significantly different from the public (large) firms in the sense that they are less efficient.

Usually, it is argued that larger firms have more problems to adjust, and that on the other hand a good business environment - the country and the industry is growing – could help poorly performing firms to actually maintain productivity level because it may be easier to release workers and capital to other firms. This argument may be true when referring to firms in developed market economies, but for the two transition countries overall the market environment it is not favourable enough to help them face the competition and maintain productivity. Finally, the explanatory variable for sector, shows that all sectors – except 211 – are significantly more inefficient that the reference sector 172.

When analysing the estimates of the regressions for the other dependent variables – NPE with credit constrained profit function (NPE-CC), NPE with interest constrained profit function (NPE-I), and NPE with fixed assets constrained profit function (NPE-FA), overall the conclusions are very similar except that the values of the coefficients are in absolute terms smaller than the ones in Table 4: Bulgaria and Romania continue to behave significantly different with respect to the rest of the countries in the panel (they are less efficient), the size is a significant explanatory variable for NPE-CC and NPE-FA, but not for NPE-I while the ownership form it is not any longer significant for any of the dependent variables.

The *sectors* vary also when moving from NPE-CC to NPE-I and NPE-FA. Overall, for the explanatory variable *sector,* the results are similar for NPE and NPE-CC (almost all sectors are significantly less efficient than 172) on one hand, and for NPE-I and NPE-FA on the other hand (only two sectors 211 and 251/252 are significantly less efficient than 172).

A model similar to the one presented in Eq. (22) was used for the regression analysis at sector level. In this case, all the variables are the same, except for the dummies for industry sectors which are removed. For the estimation at sector level, we include year effects, given that the demand shocks may be correlated not only with industry and country but could vary across years. When pooling together all sectors, year was found to be not significant. For this reason the time effect was not included in Eq. (22). At industry level, the panel data model applied is the following:

$$Y_{it} = \beta_0 + \sum_{l=1}^{7} \beta_{lit} country_{lit} + \sum_{l=1}^{3} \beta_{8+l} ownership_{lit} + \sum_{l=1}^{4} \beta_{12+l} year_t + \beta_{17} size_{it} + \beta_{18} Rsh_{it} + \varepsilon_{it} \quad (23)$$

where: - $i = firms, t = time$

- $l = 1,...,3$ ownership forms (public, private, other)
- $l = 1,...,7$ countries
- Y_{it} represents in turn : NPE, NPE - CC, NPE - I, and NPE - FA.
- $size$ = the number of employees
- Rsh = the return on shareholders funds (%)
- *country* and *ownership* represent dummies for countries and ownership forms
- *year* is the dummy for time
- ε_{it} is a residual

and random effects: $w_{it} = \beta_0 + v_{it}$

$$v_{lit} = \beta_l + u_{it}$$

Similar condition as for model in expression (22) are assumed to be satisfied. The results for Eq. (23) are presented in Appendix 4.2. part (C) at the end of the chapter. In Table 6, hereafter we present the case of sector 172, when the dependent variable is NPE.

Table 6: LME model for sector 172. Dependent variable: NPE

Model - NPE	**Value**	**Std. Error**	**t-value**	**p-value**
Intercept	2.7420	0.2134	12.8459	<.0001
Country (Belgium)				
Bulgaria	**229.4932**	**48.4633**	**4.7354**	**<.0001**
France	0.3254	0.6148	0.5296	0.5968
Italy	-0.1331	0.1839	-0.7234	0.4697
Romania	**91.5331**	**10.3176**	**8.8714**	**<.0001**
Spain	**2.0345**	**0.3279**	**6.2047**	**<.0001**
Size	**-0.0027**	**0.0002**	**-9.5798**	**<.0001**
Rsh	0.0024	0.0029	0.8109	0.4177
Ownership (Public)				
Private	0.2215	0.2759	0.8028	0.4223
Other Type	-2.5098	2.1248	-1.1811	0.2380
Year (1995)				
1996	0.5254	0.2301	2.2831	0.0227
1997	0.2947	0.2299	1.2815	0.2004
1998	0.5831	0.2299	2.5358	0.0114

Bold: $p<0.05$

Overall, the main conclusions when pooling all industry sectors do not vary very much when performing the analysis for every sector separately. The values of the coefficients are in absolute terms larger when the dependent variable is NPE than for the others. The two countries Bulgaria and Romania continue to be significantly more inefficient than the rest of the countries in the data set. In very few cases, sectors 172 and 175, countries like Italy and Spain are significantly less or more efficient than Belgium, although the values of the coefficients are in absolute terms smaller than unity.

The *size* continues to be a significant explanatory variable in the same line as when pooling together all sectors: larger firms are more efficient than smaller firms. The return on shareholders funds (*Rsh*) is significant for sectors 175, 241 and 252 when the dependent variable analysed is NPE with interest constrained profit function (NPE-I). The *ownership* form is dominantly not significant and the same conclusion is valid for the *time* period. Except for the sectors 175 (NPE-CC), and 252 only the terminal year (1998) is found to be significant for most of the industrial sectors and dependent variables. It is not straightforward the intuition of why the variation across years is statistically significant only for 1998. For the transition economies, the evidence indicates that 1995-97 was a period of a relative slow down in GDP, while in 1998 the growth in GDP was positive.

Nevertheless, overall we could conclude that when moving with the analysis from global to sector level, the main conclusions still hold without important variations.

4.6. Concluding Remarks

In this chapter, once more we addressed the issue of the determinants of productive efficiency which are a key component concerning the *efficiency* both for firms in advanced market economies and in transition economies. Our measure of firm performance is the annual profit/loss calculated based on accounting procedures. The use of this performance indicator it is at the same time the value added of the present analysis.

Very often, empirical studies involving countries in transition economies use other variables like i.e. the growth of labour productivity (Earle et al.,2002), sales as a proxy for enterprise performance or structural variables such as the number of competitors, exports and joint ventures (Jones et al., 1998) especially when study the organisational efficiency. The use of more desirable performance measures like Tobin's Q or total factor productivity, is often not possible due to data availability.

We combine also in the panel data countries not only from the developed market economies but also from transition economies, in this case, Bulgaria and Romania. For these two countries there are not too many empirical studies done referring to the early post-transition period. Moreover, Romania's experience concerning the effect of privatisation policies and ownership structures on firm behaviour is one of the richest given that the privatisation process involved all methods applied in countries in transition economies.[26]

More precisely, Earle and Telegdy (2002) describe the post privatisation ownership structure in Romania and estimate its effect on firms performance. The authors distinguish different types of private owners: employees, mass privatisation participants, and investors

[26] See Earle and Telegdy (2002) for a complete description of the privatisation process in Romania.

who purchased blocks of shares. Their findings showed that private ownership has positive and significant effects on labour productivity growth.

While a great part of the empirical investigations of the determinants of productive efficiency follow mainly two basic approaches – the estimation of conventional production functions or stochastic frontiers – we applied here the non–parametric frontier approach combined with directional distance functions. We constructed a normalised measure of firm profitability (NPE) for each of the six manufacturing industry sectors, and every year over the whole time period, 1995-1998. We worked in a variable returns to scale setting and both in input and / or output orientation, and estimated the effects of variables like credits, interests paid or fixed assets on firm profitability.

From a methodological perspective, the way we define the constraints, allowing for shifts in the frontier, is another important contribution of this chapter with respect to the work of other authors like Färe et al. (1990). In this analysis, the shift inwards of the frontier is indicating that the constraints are binding. Furthermore, we relate the analysis of credit constraint to the literature on soft/hard budget constraint, concepts first introduced by Kornai in the analysis of the former socialist economies.

Our findings allow us to draw the following conclusions: first, when looking at profit efficiency performance across countries, we could see that Bulgaria and Romania are the most inefficient while the differences among the countries in the developed market economies are rather small.

Second, when measuring the firm profitability taking into account the presence of credit, interest paid and fixed assets constraints, the above conclusion remains valid: Bulgaria and Romania exhibit again a greater inefficiency in profits compared to the rest of the countries in the sample.

Third, if one compares NPE with NPE-CC, NPE-I, and NPE -FA, the conclusion is that the constraints are binding, and if we are to rank them, then the credit constraint comes first, followed by the interest paid, and finally the fixed assets constraint is the less restrictive, as expected. For this reason we decided to focus in particular on the impact of the above mentioned constraints. The objective was to see whether their influence on firms' profitability differs in a significant way when comparing countries among themselves. For this purpose we applied a *t-test*, comparing paired samples' averages. We compared for every country and each industry sector the following variables: NPE & NPE-CC, NPE & NPE-I, and NPE & NPE-FA. We found that the differences among the paired samples compared are statistically significant for almost all countries and all industries.

Moreover, the upper/lower bounds for a 95% confidence interval are much broader for the two emerging market economies – Bulgaria and Romania – while for the rest of the countries in advanced market economies very often these differences although statistically significant are in magnitude a bit larger than unity. This allows us to stress even more one previous finding concerning the greater impact of the constraints imposed on profitability when dealing with Bulgaria and Romania.

Putting into relation the literature on SBC/HBC and our evidence that the credit constraints in particular are binding in all countries analysed, and in the Eastern countries especially, we could actually say that our findings go in the same line with other empirical studies on transition economies that observed a hardening of the firms' budget constraints in the post communist period. Of course, this interpretation has to be taken with care and we have to bear in mind that the present analysis is somehow limited by the fact that many factors featuring the business environment[27] like i.e. possible corporate governance problems, dispersion of shareholdings, insiders control or bankruptcy laws, in all countries analysed, are not considered. In the case of Bulgaria and Romania these factors could play an important role in explaining why the impact of the constraints on firms' profits is much greater than in the rest of the countries in the sample.

[27] Earle and Telegdy (2002, p. 667) mention in their paper the EBRD's (2000, p.21) grading of "institutional performance" in the transition economies. In particular, the EBRD awarded Romania a score that puts this country a bit ahead Russia and well behind Hungary, Poland, and the Czech Republic.

Finally, we also estimated two models for panel data. One of them when pooling together all industries, and a second one applied for each industry separately. The estimates that are statistically significant support the conclusions already reached with the decomposition of the profit efficiency measure: the two transition economies do behave significantly different with respect to the rest of the countries belonging to developed market economies. Size (or which is the same: large (public) firms) are more efficient than the smaller ones, and there is also in some cases significant variation in profit efficiency across industries. The variations in profit efficiency among countries and industries across time is not significant in most of the cases. This somehow may be also due to the rather short time period we analyse here: four years may not be enough for a conclusive dynamic analysis.

This evidence presented, contributes nevertheless to extend the list of countries, in particular from transition economies, whose firms' performance has been analysed with methods others than parametric or stochastic. Our findings also corroborate previous results that once more stress the fact that the countries in transition economies do not all go at the same path, and Bulgaria and Romania in particular, are still well behind the performance in efficiency of the countries in advanced market economies.

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Appendix 4.1.

Average Number of Employees

Sector 172 –Textile Weaving

Country	1995	1996	1997	1998
Belgium	310	302	310	317
Bulgaria	1131	1159	1131	977
France	278	291	278	279
Italy	218	213	218	217
Romania	917	979	917	758
Spain	74	72	74	75

Sector 175 – Manufacturing of other textiles

Country	1995	1996	1997	1998
Belgium	201	191	199	225
Bulgaria	358	327	299	273
France	295	287	290	287
Italy	227	236	247	238
Netherlands	3085	3090	3220	3567
Romania	952	948	919	822
Spain	155	155	161	179

Sector 211 – Manufacturing of Pulp, Paper and Paperboard

Country	1995	1996	1997	1998
Belgium	360	345	335	319
Bulgaria	1603	1638	1067	1030
France	481	484	368	366
Italy	143	156	300	301
Netherlands	1060	1080	1260	1006
Romania	1478	1440	804	650
Spain	202	202	408	353

Sector 241 – Manufacturing of Basic Chemicals

Country	1995	1996	1997	1998
Belgium	691	500	496	496
Bulgaria	1045	1053	1001	914
France	342	331	311	311
Italy	238	240	210	208
Netherlands	1298	1421	1347	1457
Romania	2267	2234	2101	1823
Spain	399	378	352	352

Sector 251 - Manufacturing of Rubber Products

Country	1995	1996	1997	1998
Belgium	209	209	218	237
Bulgaria	2869	3000	2551	2203
France	513	517	512	513
Italy	339	364	374	393
Netherlands	8215	7914	7906	7706
Romania	1166	1155	1082	869
Spain	1134	1127	1136	1143

Sector 252 - Manufacturing of Plastic Products

Country	1995	1996	1997	1998
Belgium	127	127	130	135
Bulgaria	609	597	562	517
France	278	281	280	302
Italy	154	175	184	175
Netherlands	1260	1326	1295	1576
Romania	949	928	865	745
Spain	237	244	243	255

Appendix 4.2.

A) Panel Data: T-Test Results per Sector and Country

- Sector 172 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	0.3016	0.7216	<0.001
	Pair 2 NPE – NPEI	1.6137	2.2940	<0.001
	Pair 3 NPE - NPEFA	1.2689	1.8706	<0.001
Bulgaria	Pair 1 NPE – NPECC	108.9556	286.5606	<0.001
	Pair 2 NPE – NPEI	129.0447	327.4763	<0.001
	Pair 3 NPE - NPEFA	125.0271	319.0397	<0.001
France	Pair 1 NPE – NPECC	0.6536	2.3235	<0.001
	Pair 2 NPE – NPEI	1.1226	3.3062	<0.001
	Pair 3 NPE - NPEFA	.9528	2.9762	<0.001
Italy	Pair 1 NPE – NPECC	0.3974	0.6267	<0.001
	Pair 2 NPE – NPEI	1.7144	2.0798	<0.001
	Pair 3 NPE - NPEFA	1.6420	1.9560	<0.001
Romania	Pair 1 NPE – NPECC	56.5977	92.3230	<0.001
	Pair 2 NPE – NPEI	69.3074	109.9801	<0.001
	Pair 3 NPE - NPEFA	66.4964	105.9012	<0.001
Spain	Pair 1 NPE – NPECC	1.4857	2.4872	<0.001
	Pair 2 NPE – NPEI	3.7975	4.9401	<0.001
	Pair 3 NPE - NPEFA	3.5201	4.5786	<0.001

- Sector 175 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	1.4462	2.0122	<0.001
	Pair 2 NPE – NPEI	2.7448	3.7337	<0.001
	Pair 3 NPE - NPEFA	3.0937	2.0122	<0.001
Bulgaria	Pair 1 NPE – NPECC	275.2779	976.2219	0.002
	Pair 2 NPE – NPEI	324.3898	1245.2255	0.003
	Pair 3 NPE - NPEFA	324.9084	1249.5289	0.003
France	Pair 1 NPE – NPECC	2.0770	3.0074	<0.001
	Pair 2 NPE – NPEI	3.1451	4.4633	<0.001
	Pair 3 NPE - NPEFA	3.3698	4.7525	<0.001
Italy	Pair 1 NPE – NPECC	2.0640	2.5724	<0.001
	Pair 2 NPE – NPEI	2.8645	2.5724	<0.001
	Pair 3 NPE - NPEFA	4.0393	4.8044	<0.001
Netherlands	Pair 1 NPE – NPECC	2.702E-02	0.3026	0.022
	Pair 2 NPE – NPEI	4.795E-02	0.5792	0.024
	Pair 3 NPE - NPEFA	4.391E-02	0.7914	0.031
Romania	Pair 1 NPE – NPECC	107.0282	260.3342	<0.001
	Pair 2 NPE – NPEI	141.0806	260.3342	<0.001
	Pair 3 NPE - NPEFA	145.6883	322.2781	<0.001
Spain	Pair 1 NPE – NPECC	2.7308	4.6813	<0.001
	Pair 2 NPE – NPEI	4.0716	6.2738	<0.001
	Pair 3 NPE - NPEFA	5.2695	7.6086	<0.001

- Sector 211 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	0.4352	1.4181	0.001
	Pair 2 NPE – NPEI	9.384E-02	2.0757	0.033
	Pair 3 NPE - NPEFA	1.1835	2.7341	<0.001
Bulgaria	Pair 1 NPE – NPECC	-12.2935	229.3195	0.075
	Pair 2 NPE – NPEI	-113.0291	218.4395	0.075
	Pair 3 NPE - NPEFA	-9.4571	245.2820	0.067
France	Pair 1 NPE – NPECC	1.3596	2.3606	<0.001
	Pair 2 NPE – NPEI	0.7648	2.1402	<0.001
	Pair 3 NPE - NPEFA	1.7096	2.8389	<0.001
Italy	Pair 1 NPE – NPECC	1.5547	2.1515	<0.001
	Pair 2 NPE – NPEI	1.0117	1.9721	<0.001
	Pair 3 NPE - NPEFA	2.5273	3.2739	<0.001
Netherlands	Pair 1 NPE – NPECC	0.1183	1.4731	0.023
	Pair 2 NPE – NPEI	-0.1946	1.6327	0.023
	Pair 3 NPE - NPEFA	0.5038	2.0348	0.002
Romania	Pair 1 NPE – NPECC	15.3992	64.6507	0.002
	Pair 2 NPE – NPEI	-35.0314	48.5098	0.747
	Pair 3 NPE - NPEFA	18.4584	69.4368	0.001
Spain	Pair 1 NPE – NPECC	1.5870	2.4744	<0.001
	Pair 2 NPE – NPEI	1.1572	2.7329	<0.001
	Pair 3 NPE - NPEFA	2.7596	4.0078	<0.001

- Sector 241 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	4.9308	7.4215	<0.001
	Pair 2 NPE – NPEI	6.7217	7.4215	<0.001
	Pair 3 NPE - NPEFA	7.1923	10.7865	<0.001
Bulgaria	Pair 1 NPE – NPECC	126.0673	3001.0076	0.034
	Pair 2 NPE – NPEI	141.7410	3220.3846	0.034
	Pair 3 NPE - NPEFA	146.8097	3227.3063	0.033
France	Pair 1 NPE – NPECC	6.7913	8.5071	<0.001
	Pair 2 NPE – NPEI	8.0413	9.9159	<0.001
	Pair 3 NPE - NPEFA	8.3045	10.2612	<0.001
Italy	Pair 1 NPE – NPECC	8.0037	9.2544	<0.001
	Pair 2 NPE – NPEI	10.2125	11.7956	<0.001
	Pair 3 NPE - NPEFA	11.1209	12.7912	<0.001
Netherlands	Pair 1 NPE – NPECC	3.1561	6.4560	<0.001
	Pair 2 NPE – NPEI	3.1561	8.8743	<0.001
	Pair 3 NPE - NPEFA	4.5482	9.1427	<0.001
Romania	Pair 1 NPE – NPECC	196.1178	329.6540	<0.001
	Pair 2 NPE – NPEI	213.9275	357.7210	<0.001
	Pair 3 NPE - NPEFA	220.9319	366.3058	<0.001
Spain	Pair 1 NPE – NPECC	6.8577	12.3909	<0.001
	Pair 2 NPE – NPEI	8.9014	16.1599	<0.001
	Pair 3 NPE - NPEFA	9.4211	17.0069	<0.001

- Sector 251 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	3.0835	13.4789	0.004
	Pair 2 NPE – NPEI	4.1679	16.0459	0.002
	Pair 3 NPE - NPEFA	3.2681	11.2719	0.002
Bulgaria	Pair 1 NPE – NPECC	-290.3071	2193.3750	0.113
	Pair 2 NPE – NPEI	-245.5602	2286.9405	0.113
	Pair 3 NPE - NPEFA	-351.7190	2160.2492	0.132
France	Pair 1 NPE – NPECC	7.7065	9.8669	<0.001
	Pair 2 NPE – NPEI	9.0564	11.4236	<0.001
	Pair 3 NPE - NPEFA	6.4030	8.0424	<0.001
Italy	Pair 1 NPE – NPECC	7.2362	8.7432	<0.001
	Pair 2 NPE – NPEI	8.0877	9.7341	<0.001
	Pair 3 NPE - NPEFA	6.3073	7.4982	<0.001
Netherlands	Pair 1 NPE – NPECC	0.1418	4.2065	0.038
	Pair 2 NPE – NPEI	0.2769	5.3948	0.033
	Pair 3 NPE - NPEFA	0.3143	4.0440	0.026
Romania	Pair 1 NPE – NPECC	330.5017	605.6596	<0.001
	Pair 2 NPE – NPEI	353.1120	643.3534	<0.001
	Pair 3 NPE - NPEFA	293.4033	572.6480	<0.001
Spain	Pair 1 NPE – NPECC	6.8972	10.8650	<0.001
	Pair 2 NPE – NPEI	8.2000	12.5480	<0.001
	Pair 3 NPE - NPEFA	6.2576	9.5466	<0.001

- Sector 252 -

Country	Paired Samples	95% Confidence Interval of the Difference		Significance (2 – tailed)
		Lower	Upper	
Belgium	Pair 1 NPE – NPECC	4.5884	5.9126	<0.001
	Pair 2 NPE – NPEI	6.5359	7.9884	<0.001
	Pair 3 NPE - NPEFA	7.2213	8.6814	<0.001
Bulgaria	Pair 1 NPE – NPECC	749.6470	1960.4841	<0.001
	Pair 2 NPE – NPEI	823.6631	2068.4869	<0.001
	Pair 3 NPE - NPEFA	837.4663	2087.0821	<0.001
France	Pair 1 NPE – NPECC	4.6542	5.8070	<0.001
	Pair 2 NPE – NPEI	5.3719	6.5655	<0.001
	Pair 3 NPE - NPEFA	5.9610	7.2165	<0.001
Italy	Pair 1 NPE – NPECC	3.4543	3.8760	<0.001
	Pair 2 NPE – NPEI	4.3452	4.7788	<0.001
	Pair 3 NPE - NPEFA	5.5686	6.0456	<0.001
Netherlands	Pair 1 NPE – NPECC	0.8021	2.1141	<0.001
	Pair 2 NPE – NPEI	1.4396	3.1252	<0.001
	Pair 3 NPE - NPEFA	1.7676	3.6380	<0.001
Romania	Pair 1 NPE – NPECC	183.1486	265.0031	<0.001
	Pair 2 NPE – NPEI	193.9630	276.9802	<0.001
	Pair 3 NPE - NPEFA	203.8714	289.0157	<0.001
Spain	Pair 1 NPE – NPECC	3.7858	5.7248	<0.001
	Pair 2 NPE – NPEI	5.4694	7.8437	<0.001
	Pair 3 NPE - NPEFA	6.6200	9.1778	<0.001

B) Panel Data: Linear Mixed Effects (LME) Model Results Analysis considering all industry sectors

Dependent variable – Nerlovian Profit Efficiency (NPE)

Model: NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	-66.4814	21.0440	-3.1591	0.0016
Country (Belgium)				
Bulgaria	**967.5620**	**38.1553**	**25.3585**	**<.0001**
France	-17.5938	20.3304	-0.8653	0.3869
Italy	-17.6304	18.5703	-0.9493	0.3425
Netherlands	17.3080	40.8485	0.4237	0.6718
Romania	**270.2539**	**20.1561**	**13.4080**	**<.0001**
Spain	1.1771	22.5315	0.0522	0.9583
Size	**-0.0314**	**0.0039**	**-7.9661**	**<.0.001**
Rsh	-0.0900	0.1334	-0.6745	0.5000
Ownership (Public)				
Private	**66.6304**	**18.5192**	**3.5978**	**0.0003**
Other Type	41.2971	27.2216	1.5170	0.1293
Sector (172)				
175	**76.6001**	**21.1670**	**3.6188**	**0.0003**
211	52.5757	21.9668	2.3934	0.0167
241	**123.5260**	**18.8338**	**6.5587**	**<.0001**
251	**156.5639**	**22.3270**	**7.0123**	**<.0001**
252	**89.0109**	**17.4309**	**5.1064**	**<.0001**

Bold: $p<0.05$

Dependent variable – Nerlovian Profit Efficiency with Credit Constraint (NPE-CC)

Model : NPE- CC	Value	Std. Error	t-value	p-value
Intercept	-4.7900	2.1837	-2.1935	0.0283
Country (Belgium)				
Bulgaria	**97.4300**	**3.9593**	**24.6075**	**<.0001**
France	-1.3172	2.1096	-0.6243	0.5324
Italy	-1.3013	1.9270	-0.6753	0.4995
Netherlands	0.7531	4.2388	0.1776	0.8590
Romania	**33.6274**	**2.0915**	**16.0774**	**<.0001**
Spain	0.6320	2.3380	0.2703	0.7869
Size	**-0.0032**	**0.0004**	**-7.8154**	**<.0001**
Rsh	-0.0148	0.0138	-1.0700	0.2847
Ownership (Public)				
Private	6.4818	1.9217	3.3729	0.0007
Other Type	1.5911	2.8247	0.5632	0.5733
Sector (172)				
175	**14.9646**	**2.1964**	**6.8129**	**<.0001**
211	**10.8183**	**2.2794**	**4.7459**	**<.0001**
241	**10.4245**	**1.9543**	**5.3339**	**<.0001**
251	**11.2656**	**2.3168**	**4.8624**	**<.0001**
252	**7.2619**	**1.8088**	**4.0147**	**0.0001**

Bold: $p<0.05$

Dependent variable – Nerlovian Profit Efficiency with Interest Constraint (NPE-I)

Model : NPE-I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	-3.3238	1.8254	-1.8208	0.0687
Country (Belgium)				
Bulgaria	**28.2841**	**3.3097**	**8.5457**	**<.0001**
France	-1.2457	1.7635	-0.7064	0.4800
Italy	-0.5300	1.6108	-0.3290	0.7421
Netherlands	-1.3301	3.5433	-0.3753	0.7074
Romania	**13.5305**	**1.7484**	**7.7387**	**<.0001**
Spain	-1.4257	1.9544	-0.7294	0.4657
Size	-0.0009	0.0003	-2.7001	0.0070
Rsh	0.0077	0.0115	0.6657	0.5056
Ownership (Public)				
Private	0.1157	1.6064	0.0720	0.9426
Other Type	-0.1096	2.3612	-0.0464	0.9630
Sector (172)				
175	4.2422	1.8361	2.3104	0.0209
211	**16.8579**	**1.9054**	**8.8470**	**<.0001**
241	4.1378	1.6337	2.5327	0.0113
251	5.1082	1.9367	2.6375	0.0084
252	**5.5513**	**1.5120**	**3.6714**	**0.0002**

Bold: $p<0.05$

Dependent variable – Nerlovian Profit Efficiency with Fixed Assets Constraint (NPE-FA)

Model : NPE-FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	-0.6358	1.4546	-0.4370	0.6621
Country (Belgium)				
Bulgaria	**23.6937**	**2.6374**	**8.9834**	**<.0001**
France	-2.2104	1.4053	-1.5729	0.1158
Italy	-1.7377	1.2836	-1.3537	0.1759
Netherlands	-0.5103	2.8236	-0.1807	0.8566
Romania	**13.4540**	**1.3932**	**9.6562**	**<.0001**
Spain	-2.3210	1.5574	-1.4902	0.1362
Size	**-0.0013**	**0.0002**	**-5.0427**	**<.0001**
Rsh	-0.0060	0.0092	-0.6531	0.5137
Ownership (Public)				
Private	-0.1552	1.2801	-0.1213	0.9035
Other Type	-2.3972	1.8816	-1.2740	0.2027
Sector (172)				
175	1.0657	1.4631	0.7283	0.4664
211	**9.7502**	**1.5184**	**6.4211**	**<.0001**
241	0.6804	1.3018	0.5226	0.6012
251	**22.2204**	**1.5433**	**14.3974**	**<.0001**
252	1.4338	1.2049	1.1901	0.2341

Bold: $p<0.05$

C) Panel Data: Linear Mixed Effects (LME) Model Results
Per sector analysis

- Sector 172 -

Model - NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**2.7420**	**0.2134**	**12.8459**	**<.0001**
Country (Belgium)				
Bulgaria	**229.4932**	**48.4633**	**4.7354**	**<.0001**
France	0.3254	0.6148	0.5296	0.5968
Italy	-0.1331	0.1839	-0.7234	0.4697
Romania	**91.5331**	**10.3176**	**8.8714**	**<.0001**
Spain	**2.0345**	**0.3279**	**6.2047**	**<.0001**
Size	**-0.0027**	**0.0002**	**-9.5798**	**<.0001**
Rsh	0.0024	0.0029	0.8109	0.4177
Ownership (Public)				
Private	0.2215	0.2759	0.8028	0.4223
Other Type	-2.5098	2.1248	-1.1811	0.2380
Year (1995)				
1996	0.5254	0.2301	2.2831	0.0227
1997	0.2947	0.2299	1.2815	0.2004
1998	0.5831	0.2299	2.5358	0.0114

Bold: p<0.05

Model : NPE -CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**2.0430**	**0.1497**	**13.6443**	**<.0001**
Country (Belgium)				
Bulgaria	**31.4767**	**5.1007**	**6.1710**	**<.0001**
France	**-0.7484**	**0.2056**	**-3.6388**	**0.0003**
Italy	0.0090	0.1354	0.0665	0.9470
Romania	**17.0336**	**1.4860**	**11.4625**	**<.0001**
Spain	**0.8442**	**0.2174**	**3.8833**	**0.0001**
Size	**-0.0017**	**0.0001**	**-9.4420**	**<.0001**
Rsh	-0.0028	0.0020	-1.3426	0.1799
Ownership (Public)				
Private	0.0809	0.2039	0.3970	0.6914
Other Type	-0.8291	0.6453	-1.2848	0.1993
Year (1995)				
1996	0.3967	0.1600	2.4792	0.0134
1997	0.2619	0.1601	1.6357	0.1024
1998	0.5232	0.1600	3.2694	0.0011

Bold: p<0.05

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**0.3868**	**0.0353**	**10.9576**	**<.0001**
Country (Belgium)				
Bulgaria	**1.2188**	**0.2606**	**4.6767**	**<.0001**
France	-0.0460	0.0357	-1.2881	0.1981
Italy	**0.2156**	**0.0434**	**4.9691**	**<.0001**
Romania	**2.4082**	**0.1402**	**17.1673**	**<.0001**
Spain	**0.2562**	**0.0615**	**4.1612**	**<.0001**
Size	**-0.0002**	**0.0004**	**-5.9652**	**<.0001**
Rsh	**-0.0022**	**0.0005**	**-4.4764**	**<.0001**
Ownership (Public)				
Private	0.0356	0.0788	0.4524	0.6511
Other Type	-0.1369	0.1012	-1.3530	0.1765
Year (1995)				
1996	0.0667	0.0408	1.6321	0.1031
1997	0.0550	0.0411	1.3390	0.1810
1998	0.0119	0.0410	0.2923	0.7702

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**0.8249**	**0.0641**	**12.8538**	**<.0001**
Country (Belgium)				
Bulgaria	**7.2051**	**2.0012**	**3.6003**	**0.0003**
France	-0.1748	0.0798	-2.1910	0.0288
Italy	-0.0138	0.0764	-0.1813	0.8562
Romania	**5.5864**	**0.7050**	**7.9235**	**<.0001**
Spain	0.1356	0.0865	1.5680	0.1173
Size	**-0.0004**	**0.0008**	**-5.1100**	**<.0001**
Rsh	-0.0010	0.0009	-1.0781	0.2814
Ownership (Public)				
Private	-0.3065	0.1408	-2.1769	0.0298
Other Type	-0.2978	0.2504	-1.1891	0.2348
Year (1995)				
1996	0.0289	0.0749	0.3860	0.6996
1997	-0.0010	0.0755	-0.0139	0.9889
1998	0.0573	0.0754	0.7603	0.4473

Bold: p<0.05

- Sector 175 -

Model : NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	4.2313	13.4757	0.3139	0.7536
Country (Belgium)				
Bulgaria	**763.4741**	**45.8430**	**16.6541**	**<.0001**
France	39.5711	20.3010	1.9492	0.0517
Italy	-35.4237	22.1575	-1.5987	0.1104
Netherlands	42.6970	44.7696	0.9537	0.3406
Romania	**127.6015**	**23.1299**	**5.5167**	**<.0001**
Spain	-18.5328	46.5423	-0.3981	0.6906
Size	-0.0556	0.0108	-5.1467	<.0001
Rsh	0.1194	0.1898	0.6288	0.5297
Ownership (Public)				
Private	**207.8031**	**42.4453**	**4.8957**	**<.0001**
Other Type	-38.2481	39.5819	-0.9663	0.3343
Year (1995)				
1996	4.8931	6.1055	0.8014	0.4232
1997	22.0812	6.8320	3.2320	0.0013
1998	**55.7503**	**9.3088**	**5.9889**	**<.0001**

Bold: p<0.05

Model : NPE - CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	1.6753	8.8126	0.1910	0.8493
Country (Belgium)				
Bulgaria	**166.8981**	**20.1063**	**8.3007**	**<.0001**
France	-0.0552	9.5873	-0.0057	0.9954
Italy	0.3506	8.8105	0.0397	0.9683
Netherlands	-0.0719	12.2877	-0.0058	0.9953
Romania	**52.7311**	**10.3287**	**5.1052**	**<.0001**
Spain	1.0428	14.8700	0.0701	0.9441
Size	**-0.0008**	**0.0001**	**-4.3752**	**<.0001**
Rsh	-0.0079	0.0061	-1.2947	0.1959
Ownership (Public)				
Private	-0.2806	0.4250	-0.6601	0.5094
Other Type	-1.0031	7.1906	-0.1394	0.8891
Year (1995)				
1996	**1.5977**	**0.3889**	**4.1078**	**<.0001**
1997	**1.7517**	**0.3885**	**4.5084**	**<.0001**
1998	**2.7651**	**0.3870**	**7.1449**	**<.0001**

Bold: p<0.05

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**1.2823**	**0.1889**	**6.7877**	**<.0001**
Country (Belgium)				
Bulgaria	**4.2432**	**0.8560**	**4.9565**	**<.0001**
France	0.3304	0.2523	1.3097	0.1907
Italy	**0.8403**	**0.1612**	**5.2118**	**<.0001**
Netherlands	-0.9220	1.7998	-0.5122	0.6086
Romania	**6.9231**	**0.5040**	**13.7361**	**<.0001**
Spain	**1.3865**	**0.3364**	**4.1206**	**<.0001**
Size	-0.0011	0.0010	-1.1259	0.2606
Rsh	-0.0093	0.0025	-3.7298	0.0002
Ownership (Public)				
Private	0.1577	0.2439	0.6468	0.5180
Other Type	-0.6934	0.4275	-1.6221	0.1053
Year (1995)				
1996	0.1571	0.1837	0.8552	0.3928
1997	0.6571	0.1857	3.5384	0.0004
1998	**1.5588**	**0.1870**	**8.3334**	**<.0001**

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	**1.2201**	**0.1779**	**6.8576**	**<.0001**
Country (Belgium)				
Bulgaria	**6.6672**	**0.5413**	**12.3160**	**<.0001**
France	0.2128	0.2533	0.8400	0.4012
Italy	0.0652	0.1745	0.3736	0.7088
Netherlands	0.3893	0.9620	0.4046	0.6858
Romania	**4.8776**	**0.3178**	**15.3441**	**<.0001**
Spain	0.1711	0.2938	0.5823	0.5605
Size	-0.0012	0.0003	-3.4002	0.0007
Rsh	-0.0071	0.0025	-2.7699	0.0058
Ownership (Public)				
Private	-0.8248	0.2750	-2.9989	0.0028
Other Type	-0.2537	0.3938	-0.6442	0.5197
Year (1995)				
1996	0.1031	0.1944	0.5303	0.5961
1997	0.3146	0.1953	1.6109	0.1077
1998	0.3154	0.1960	1.6085	0.1082

Bold: p<0.05

- Sector 211 -

Model : NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	2.8042	20.4409	0.1371	0.8909
Country (Belgium)				
Bulgaria	**216.8324**	**28.7574**	**7.5400**	**<.0001**
France	0.1583	20.7717	0.0076	0.9939
Italy	1.2474	20.4401	0.0610	0.9514
Netherlands	-1.5361	22.3524	-0.0687	0.9452
Romania	**96.0840**	**23.9117**	**4.0182**	**0.0001**
Spain	1.9780	23.5295	0.0840	0.9330
Size	-0.0001	0.0002	-0.2126	0.8317
Rsh	-0.0018	0.0029	-0.6181	0.5367
Ownership (Public)				
Private	0.8350	0.4878	1.7114	0.0875
Other Type	1.2875	9.5139	0.1353	0.8924
Year (1995)				
1996	-1.3048	0.4878	-2.6748	0.0077
1997	1.5503	0.4874	3.1806	0.0015
1998	1.0441	0.4862	2.1472	0.0322

Bold: p<0.05

Model : NPE - CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	0.9729	17.5903	0.0553	0.9559
Country (Belgium)				
Bulgaria	**109.1635**	**24.7797**	**4.4053**	**<.0001**
France	-0.5428	17.8819	-0.0303	0.9758
Italy	0.5019	17.5899	0.0285	0.9772
Netherlands	-0.9292	19.1740	-0.0484	0.9614
Romania	56.9187	20.5098	2.7751	0.0057
Spain	0.9569	20.1998	0.0473	0.9622
Size	0.0001	0.00001	0.7253	0.4685
Rsh	-0.0032	0.0018	-1.7110	0.0876
Ownership (Public)				
Private	0.2627	0.3146	0.8349	0.4041
Other Type	0.1211	8.2759	0.0146	0.9883
Year (1995)				
1996	0.4441	0.3147	1.4110	0.1588
1997	0.3473	0.3145	1.1042	0.2700
1998	**3.6687**	**0.3137**	**11.6931**	**<.0001**

Bold: p<0.05

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	0.5111	29.2873	0.0174	0.9861
Country (Belgium)				
Bulgaria	**165.0306**	**41.2782**	**3.9980**	**0.0001**
France	-0.1252	29.7771	-0.0042	0.9966
Italy	0.9331	29.2868	0.0318	0.9746
Netherlands	-0.9998	31.8857	-0.0313	0.9750
Romania	90.2912	34.1055	2.6474	0.0083
Spain	1.1447	33.6012	0.0340	0.9728
Size	0.0001	0.00002	0.6081	0.5434
Rsh	-0.0021	0.0027	-0.7795	0.4360
Ownership (Public)				
Private	0.4808	0.4566	1.0530	0.2928
Other Type	0.7695	13.8354	0.0556	0.9557
Year (1995)				
1996	-0.9388	0.4568	-2.0547	0.0404
1997	-0.3379	0.4565	-0.7402	0.4595
1998	**7.0746**	**0.4554**	**15.5337**	**<.0001**

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	-0.0939	17.8219	-0.0052	0.9958
Country (Belgium)				
Bulgaria	**100.6852**	**25.1210**	**4.0080**	**0.0001**
France	-0.0552	18.1204	-0.0030	0.9976
Italy	0.3671	17.8216	0.0206	0.9836
Netherlands	-0.5961	19.3985	-0.0307	0.9755
Romania	53.9505	20.7488	2.6001	0.0096
Spain	0.5314	20.4433	0.0259	0.9793
Size	0.0001	0.0001	0.7040	0.4817
Rsh	-0.0012	0.0016	-0.7692	0.4420
Ownership (Public)				
Private	0.3270	0.2701	1.2106	0.2265
Other Type	0.4893	8.4258	0.0580	0.9537
Year (1995)				
1996	0.0566	0.2702	0.2092	0.8344
1997	0.0340	0.2700	0.1260	0.8998
1998	**4.8239**	**0.2694**	**17.9036**	**<.0001**

Bold: p<0.05

- Sector 241 -

Model : NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	15.761	98.1659	0.1605	0.8725
Country (Belgium)				
Bulgaria	**1682.845**	**181.7226**	**9.2605**	**<.0001**
France	0.0720	102.5780	0.0006	0.9994
Italy	0.4030	98.1632	0.0041	0.9967
Netherlands	3.6660	120.3418	0.0304	0.9757
Romania	297.7860	111.3920	2.6733	0.0076
Spain	2.801	168.6708	0.0166	0.9868
Size	**-0.0080**	**0.0009**	**-8.4189**	**<.0001**
Rsh	0.0040	0.0120	0.3550	0.7226
Ownership (Public)				
Private	0.9320	0.9686	0.9619	0.3363
Other Type	-6.3150	60.5308	-0.1043	0.9169
Year (1995)				
1996	-3.6100	1.1197	-3.2239	0.0013
1997	-2.1270	1.1191	-1.9004	0.0576
1998	-2.7480	1.1195	-2.4550	0.0142

Bold: p<0.05

Model : NPE - CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	9.6485	7.3209	1.3179	0.1878
Country (Belgium)				
Bulgaria	**173.4371**	**15.0765**	**11.5037**	**<.0001**
France	-2.6919	7.6098	-0.3537	0.7236
Italy	-1.9251	7.3125	-0.2632	0.7924
Netherlands	10.8291	7.5157	1.4409	0.1499
Romania	**31.0035**	**7.7433**	**4.0038**	**0.0001**
Spain	5.6513	11.4124	0.4951	0.6206
Size	**-0.0118**	**0.0010**	**-11.6388**	**<.0001**
Rsh	-0.0151	0.0040	-3.7105	0.0002
Ownership (Public)				
Private	-0.1533	0.3571	-0.4292	0.6679
Other Type	-0.2185	4.5702	-0.0478	0.9619
Year (1995)				
1996	**-2.5225**	**0.3559**	**-7.0863**	**<.0001**
1997	**-2.5387**	**0.3539**	**-7.1726**	**<.0001**
1998	**-2.2628**	**0.3574**	**-6.3296**	**<.0001**

Bold: p<0.05

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	1.5155	0.5307	2.8552	0.0044
Country (Belgium)				
Bulgaria	**6.99953**	**0.8748**	**7.9956**	**<.0001**
France	-0.5309	0.5265	-1.0083	0.3135
Italy	0.1933	0.5304	0.3645	0.7155
Netherlands	-0.0666	0.9416	-0.0708	0.9436
Romania	**9.3040**	**0.7121**	**13.0652**	**<.0001**
Spain	-0.1377	1.2406	-0.1110	0.9116
Size	**-0.0005**	**0.00007**	**-7.9170**	**<.0001**
Rsh	**-0.0061**	**0.0014**	**-4.2239**	**<.0001**
Ownership (Public)				
Private	-0.0790	0.1962	-0.4030	0.6870
Other Type	-0.2801	0.1502	-1.8646	0.0625
Year (1995)				
1996	0.3519	0.1440	2.4432	0.0147
1997	0.2136	0.1442	1.4813	0.1388
1998	0.0831	0.1441	0.5763	0.5645

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	0.6155	0.2043	3.0121	0.0027
Country (Belgium)				
Bulgaria	**1.4027**	**0.3489**	**4.0202**	**0.0001**
France	-0.1200	0.2049	-0.5860	0.5580
Italy	0.0322	0.2027	0.1591	0.8736
Netherlands	-0.0527	0.3205	-0.1645	0.8693
Romania	**1.4227**	**0.2582**	**5.5087**	**<.0001**
Spain	-0.0956	0.4329	-0.2208	0.8252
Size	**-0.0001**	**0.00002**	**-4.3955**	**<.0001**
Rsh	**-0.0029**	**0.0005**	**-5.5050**	**<.0001**
Ownership (Public)				
Private	-0.0015	0.0533	-0.0294	0.9765
Other Type	-0.0309	0.0798	-0.3876	0.6984
Year (1995)				
1996	0.0069	0.0521	0.1340	0.8934
1997	0.0069	0.0521	-0.6904	0.4900
1998	**0.3919**	**0.0521**	**7.5138**	**<.0001**

Bold: p<0.05

- Sector 251 -

Model : NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	0.6155	0.2043	3.0121	0.0027
Country (Belgium)				
Bulgaria	**1.4027**	**0.3489**	**4.0202**	**0.0001**
France	-0.1200	0.2049	-0.5860	0.5580
Italy	0.0322	0.2027	0.1591	0.8736
Netherlands	-0.0527	0.3205	-0.1645	0.8693
Romania	**1.4227**	**0.2582**	**5.5087**	**<.0001**
Spain	-0.0956	0.4329	-0.2208	0.8252
Size	**-0.0001**	**0.00002**	**-4.3955**	**<.0001**
Rsh	**-0.0029**	**0.0005**	**-5.5050**	**<.0001**
Ownership (Public)				
Private	-0.0015	0.0533	-0.0294	0.9765
Other Type	-0.0309	0.0798	-0.3876	0.6984
Year (1995)				
1996	0.0069	0.05212	0.1340	0.8934
1997	-0.0360	0.05215	-0.6904	0.4900
1998	**0.3919**	**0.05216**	**7.5138**	**<.0001**

Bold: $p<0.05$

Model : NPE - CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	4.5133	10.4948	0.4300	0.6673
Country (Belgium)				
Bulgaria	**74.3593**	**13.0691**	**5.6896**	**<.0001**
France	-0.4715	10.4930	-0.0449	0.9642
Italy	-0.4143	10.6144	-0.0390	0.9689
Netherlands	9.2826	15.2804	0.6074	0.5438
Romania	40.2769	11.7151	3.4380	0.0006
Spain	1.6983	14.5394	0.1168	0.9071
Size	**-0.0014**	**0.0002**	**-6.1942**	**<.0001**
Rsh	-0.0010	0.0041	-0.2539	0.7996
Ownership (Public)				
Private	1.2587	3.0293	0.4155	0.6779
Other Type	0.6381	0.3504	1.8206	0.0692
Year (1995)				
1996	**-2.2855**	**0.4367**	**-5.2335**	**<.0001**
1997	**-2.1947**	**0.4373**	**-5.0181**	**<.0001**
1998	-0.0261	0.4366	-0.0599	0.9522

Bold: $p<0.05$

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	1.3379	1.4568	0.9184	0.3588
Country (Belgium)				
Bulgaria	4.2793	1.8473	2.3165	0.0209
France	-0.1966	1.4559	-0.1350	0.8926
Italy	0.6910	1.4666	0.4711	0.6377
Netherlands	1.9007	2.0332	0.9348	0.3503
Romania	**11.1012**	**1.5970**	**6.9511**	**<.0001**
Spain	1.0286	1.9403	0.5301	0.5962
Size	**-0.0003**	**0.00005**	**-5.8352**	**<.0001**
Rsh	-0.0037	0.0011	-3.2289	0.0013
Ownership (Public)				
Private	0.0386	0.3478	0.1111	0.9116
Other Type	0.0008	0.0982	0.0084	0.9933
Year (1995)				
1996	-0.1140	0.1201	-0.9498	0.3426
1997	0.0081	0.1202	0.0675	0.9462
1998	0.1680	0.1201	1.3990	0.1624

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	4.8247	13.1474	0.3669	0.7138
Country (Belgium)				
Bulgaria	**122.9693**	**16.4003**	**7.4979**	**<.0001**
France	0.3024	13.1447	0.0230	0.9817
Italy	0.1999	13.2914	0.0150	0.9880
Netherlands	15.9921	19.0639	0.8388	0.4019
Romania	**75.2729**	**14.6510**	**5.1377**	**<.0001**
Spain	2.6067	18.1476	0.1436	0.8858
Size	**-0.0024**	**0.0003**	**-7.7217**	**<.0001**
Rsh	-0.0057	0.0057	-0.9872	0.3240
Ownership (Public)				
Private	0.0234	3.7338	0.0062	0.9950
Other Type	0.9201	0.4817	1.9098	0.0567
Year (1995)				
1996	-0.2089	0.5998	-0.3482	0.7278
1997	-0.4537	0.6007	-0.7552	0.4504
1998	0.0670	0.5998	0.1116	0.9111

Bold: p<0.05

- Sector 252 -

Model : NPE	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	9.5920	32.4524	0.2955	0.7676
Country (Belgium)				
Bulgaria	**1457.9590**	**65.6426**	**22.2105**	**<.0001**
France	-1.1440	33.2626	-0.0343	0.9726
Italy	-2.4330	32.4519	-0.0749	0.9402
Netherlands	2.4890	42.5104	0.0585	0.9533
Romania	**246.1000**	**37.0555**	**6.6413**	**<.0001**
Spain	0.83330	44.3344	0.0188	0.9850
Size	**-0.0070**	**0.0005**	**-13.6651**	**<.0001**
Rsh	0.0000	0.0029	-0.0456	0.9636
Ownership (Public)				
Private	**1.3430**	**0.2633**	**5.0977**	**<.0001**
Other Type	3.4740	1.4855	2.3388	0.0194
Year (1995)				
1996	0.5070	0.3171	1.5973	0.1104
1997	0.3111	0.3189	0.9738	0.3303
1998	0.0470	0.3167	0.1490	0.8816

Bold: p<0.05

Model : NPE - CC	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	2.8898	2.6321	1.0978	0.2724
Country (Belgium)				
Bulgaria	**106.7524**	**5.2483**	**20.3401**	**<.0001**
France	-1.4399	2.6882	-0.5356	0.5923
Italy	-0.7245	2.6305	-0.2754	0.7830
Netherlands	1.4280	3.6822	0.3878	0.6982
Romania	**24.1142**	**3.0768**	**7.8371**	**<.0001**
Spain	0.8346	3.7193	0.2243	0.8225
Size	**-0.0028**	**0.0002**	**-10.0725**	**<.0001**
Rsh	**-0.0072**	**0.0016**	**-4.3862**	**<.0001**
Ownership (Public)				
Private	0.2804	0.1451	1.9324	0.0535
Other Type	1.4111	0.7220	1.9543	0.0508
Year (1995)				
1996	**2.3674**	**0.1738**	**13.6143**	**<.0001**
1997	**1.4925**	**0.1748**	**8.5379**	**<.0001**
1998	**0.9310**	**0.1736**	**5.3603**	**<.0001**

Bold: p<0.05

Model : NPE - I	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	1.5835	0.7791	2.0324	0.0423
Country (Belgium)				
Bulgaria	**17.5249**	**1.5215**	**11.5181**	**<.0001**
France	-0.2119	0.7908	-0.2680	0.7887
Italy	0.3775	0.7773	0.4856	0.6273
Netherlands	1.4225	1.1917	1.1936	0.2328
Romania	**13.9464**	**0.9414**	**14.8139**	**<.0001**
Spain	0.8039	1.1495	0.6993	0.4844
Size	**-0.0017**	**0.0001**	**-11.5331**	**<.0001**
Rsh	**-0.0038**	**0.0010**	**-3.8195**	**0.0001**
Ownership (Public)				
Private	0.0308	0.0906	0.3400	0.7339
Other Type	0.6191	0.3148	1.9667	0.0494
Year (1995)				
1996	**-0.4509**	**0.1061**	**-4.2489**	**<.0001**
1997	**0.6088**	**0.1066**	**5.7107**	**<.0001**
1998	**1.1433**	**0.1060**	**10.7858**	**<.0001**

Bold: p<0.05

Model : NPE - FA	*Value*	*Std. Error*	*t-value*	*p-value*
Intercept	1.5835	0.7791	2.0324	0.0423
Country (Belgium)				
Bulgaria	**17.5249**	**1.5215**	**11.5181**	**<.0001**
France	-0.2119	0.7908	-0.2680	0.7887
Italy	0.3775	0.7773	0.4856	0.6273
Netherlands	1.4225	1.1917	1.1936	0.2328
Romania	**13.9464**	**0.9414**	**14.8139**	**<.0001**
Spain	0.8039	1.1495	0.6993	0.4844
Size	**-0.0017**	**0.0001**	**-11.5331**	**<.0001**
Rsh	**-0.0038**	**0.0010**	**-3.8195**	**0.0001**
Ownership (Public)				
Private	0.0308	0.0906	0.3400	0.7339
Other Type	0.6191	0.3148	1.9667	0.0494
Year (1995)				
1996	**-0.4509**	**0.1061**	**-4.2489**	**<.0001**
1997	**0.6088**	**0.1066**	**5.7107**	**<.0001**
1998	**1.1433**	**0.1060**	**10.7858**	**<.0001**

Bold: p<0.05

Sector 172 – Textile Weaving

1995	Input – Output Orientation				Input - Orientation				Output - Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	10.0637	3.5634	0.7048	1.2423	24.3695	8.2199	1.5734	2.7153	17.6225	6.4397	1.2977	2.3123
Belgium (+20)	1.8974	1.5562	0.3159	0.6966	4.1957	3.4337	0.6923	1.5327	3.4717	2.8520	0.5821	1.2794
Bulgaria (+7)	8.5068	5.2874	0.8230	1.7898	18.2389	11.3299	1.7384	3.8397	15.9858	9.9428	1.5679	3.3617
(-1)	6.3421	3.6341	1.2822	1.9789	12.6771	7.2641	2.5631	3.9556	12.6914	7.2723	2.5659	3.9601
France (+25)	1.4770	0.7584	0.2321	0.4467	3.4895	1.7800	0.5349	1.0515	2.5788	1.3303	0.4120	0.7813
Italy (+55)	1.8851	1.4280	0.4665	0.5179	4.9058	3.6899	1.1786	1.2717	3.1421	2.3948	0.7895	0.8910
(- 2)	11.8792	7.6047	3.6138	5.8453	14.7236	9.7434	4.5136	6.9637	78.4118	48.2480	23.6428	40.3092
Romania (+43)	30.9508	8.8247	1.4602	2.8750	75.2980	20.0964	3.1051	6.0501	54.0986	16.1133	2.7755	5.4895
(-5)	31.4604	13.6662	2.6216	5.4083	57.2775	25.1063	4.8223	9.8526	70.0050	30.1001	5.7649	12.0273
Spain (+10)	4.1208	2.5055	0.6442	0.9035	9.2671	5.5600	1.4018	2.0535	7.4735	4.5873	1.1956	1.6267
Max.Value (+)	289.939	44.9897	4.8640	9.6791	829.4180	128.7002	10.3906	20.0764	445.7665	69.1693	9.1449	18.6898
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	33.5595	5.9470	0.7463	1.5884	93.8908	15.5790	1.5750	3.3233	52.9946	10.0372	1.4321	3.0483
Total Units	168	168	168	168	168	168	168	168	168	168	168	168

1996	Input – Output Orientation				Input - Orientation				Output - Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	16.5014	5.6748	0.9663	1.5531	37.3398	12.8331	2.1522	3.4577	29.9114	10.3046	1.7749	2.8458
Belgium (+20)	2.4413	1.8914	0.3479	0.7310	5.4122	4.2053	0.7662	1.6199	4.4584	3.4454	0.6385	2.9145
Bulgaria (+8)	73.5684	21.7912	2.4148	4.7593	169.1423	49.7981	5.2890	10.8485	131.0231	38.9984	4.4635	8.5282
France (+25)	4.2947	1.5342	0.3534	0.6851	10.0772	3.6105	0.8244	1.6159	7.5129	2.6809	0.6218	1.1944
Italy (+56)	2.4816	1.8878	0.5341	0.5608	6.3848	4.8238	1.3341	1.3654	4.1492	3.1734	0.9081	0.9689
(-1)	5.7125	4.8303	1.0673	3.1491	11.3452	9.5931	2.1197	6.2541	11.5061	9.7292	2.1498	6.3429
Romania (+43)	40.3390	12.3332	1.9657	3.3021	89.5906	27.0225	4.1909	7.0836	74.1847	22.8984	3.7182	6.2134
(- 5)	84.9132	26.6999	5.8367	8.7506	160.8027	50.6539	11.0190	16.5107	181.4048	56.8834	12.5029	18.7722
Spain (+10)	5.4939	3.2769	0.6989	0.8379	12.5788	7.4104	1.5484	1.9510	9.8183	5.9082	1.2782	1.4792
Max.Value (+)	303.0954	44.3627	6.3509	8.9624	789.2852	115.5240	13.1838	20.3351	492.0480	72.0188	12.2540	16.2929
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	34.6137	8.1900	1.0995	1.9614	82.8355	18.7333	2.3213	4.2805	60.6109	14.8314	2.0994	3.6513
Total Units	168	168	168	168	168	168	168	168	168	168	168	168

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	41.3742	6.4589	1.0831	2.0395	92.1929	14.4774	2.3935	4.4407	75.6791	11.7801	1.9986	3.8007
Belgium (+20)	2.2825	1.7188	0.3297	0.6781	5.1049	3.8463	0.7313	1.5169	4.1408	3.1175	0.6021	1.2299
Bulgaria (+8)	359.0525	40.8559	1.0879	0.8054	816.742	92.8787	2.3474	1.8046	644.4918	73.3760	2.0311	1.4628
France (+25)	1.9512	0.6576	0.2604	0.4338	4.7031	1.6106	0.6167	1.0453	3.3563	1.1181	0.4535	0.7463
Italy (+55)	2.2883	1.9119	0.5484	0.5504	5.7502	4.7531	1.3379	1.3130	3.8934	3.2738	0.9487	0.9636
(- 2)	4.4889	4.4889	1.7410	3.2891	7.8970	7.8970	3.1196	5.6975	10.5191	10.5191	3.9933	7.8431
Romania (+43)	81.8217	12.2825	2.6978	5.9914	178.089	26.6156	5.7821	12.7782	152.5113	22.9476	5.0772	11.3256
(- 5)	147.9057	20.8020	5.3183	15.7601	276.878	39.0868	10.0670	29.4183	318.8807	44.6506	11.3152	34.0789
Spain (+10)	5.0199	2.8913	0.6406	0.9602	11.5320	6.4753	1.4326	2.2371	8.9555	5.2488	1.1642	1.6959
Max.Value (+)	728.0242	78.3184	7.1819	19.0822	1691.94	182.0134	14.8971	39.5811	1277.883	137.4705	13.8675	36.8455
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	105.023	12.0804	1.3826	3.1175	239.387	27.3201	2.9393	6.5804	189.2289	21.8930	2.6219	5.9500
Total Units	168	168	168	168	168	168	168	168	168	168	168	168

1998	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	66.9488	11.3104	1.1443	2.9675	145.5243	24.8184	2.5323	6.4281	124.9261	20.9942	2.1134	5.5536
Belgium (+20)	2.4892	1.8977	0.3015	0.7256	5.5829	4.2353	0.6660	1.6235	4.5077	3.4494	0.5522	1.3163
Bulgaria (+5)	446.7661	52.8661	0.2884	18.8791	948.9730	112.9151	0.6221	40.5559	845.7001	99.6299	0.5378	35.4423
(- 3)	529.0752	71.1672	2.3571	29.8083	1024.254	137.8672	4.5766	41.2140	1094.467	147.1134	4.8604	61.7091
France (+25)	2.2096	1.0283	0.2290	0.5090	5.3522	2.5296	0.5429	1.2247	3.7849	1.7427	0.3982	0.8753
Italy (+56)	2.6841	2.1801	0.5193	0.6655	7.0067	5.6759	1.3076	1.6400	4.4881	3.6549	0.8854	1.1474
(-1)	3.0269	3.0269	1.1675	1.2727	5.6368	5.6368	2.1742	2.3701	6.5375	6.5375	2.5216	2.7488
Romania (+43)	188.4391	30.5886	3.1418	7.0407	410.1668	66.1031	6.7270	14.9163	351.2337	57.2703	5.9162	13.3726
(-5)	340.1885	70.8646	6.1775	36.8088	637.1679	132.7406	11.7044	68.4487	733.7113	152.6534	13.1282	79.9457
Spain (+10)	5.2821	3.2972	0.4577	1.0177	11.8493	7.3325	1.0147	2.2959	9.5589	6.0073	0.8359	1.8328
Max.Value (+)	1021.289	117.2103	7.8684	32.6559	2198.191	252.2797	16.3096	66.8798	1907.541	222.5428	15.2030	63.8157
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	164.5773	20.4704	1.6347	5.2830	358.6178	44.2199	3.4813	11.1537	307.7806	38.4405	3.0962	10.0711
Total Units	168	168	168	168	168	168	168	168	168	168	168	168

Sector 175 – Manufacturing of other Textiles

1995	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	24.2997	2.7853	1.8686	1.4897	61.9082	6.7332	4.2998	3.3443	41.0286	4.8657	3.3633	2.7123
Belgium (+29)	3.7496	1.8178	1.0582	1.0882	8.2211	3.9999	2.3146	2.3776	6.9244	3.3444	1.9541	2.0107
Bulgaria (+2)	29.6295	3.3054	2.4537	2.6256	64.3746	7.2072	5.2660	5.6975	54.9263	6.1087	4.5962	4.8723
(-1)	53.8986	16.5256	17.4070	6.5896	107.6116	32.9944	34.7541	13.1565	107.9833	33.1084	34.8742	13.2019
France (+22)	3.9021	0.6276	0.7091	0.8936	9.9034	1.5842	1.7902	2.2417	6.4902	1.0436	1.1837	1.4946
Italy (+50)	4.6631	1.5458	1.8402	1.0694	11.8542	3.8992	4.5940	2.5284	7.8575	2.6247	3.1363	1.8732
(- 2)	10.2463	3.6213	2.2312	1.6950	16.1285	5.7775	3.6759	2.7771	28.4828	9.9042	5.8581	4.4828
Netherlands (+4)	0.4081	0.3353	0.1982	0.1811	0.9164	0.7528	0.4467	0.4082	0.7361	0.6048	0.3563	0.3255
Romania (+35)	92.9892	7.2390	3.4699	3.0664	239.8942	17.8402	7.5834	6.6247	155.8169	12.5257	6.4693	5.7458
(- 3)	22.8234	6.2904	6.4388	2.8042	44.4483	12.1789	12.4445	5.4713	46.9305	13.0129	13.3474	5.7546
Spain (+17)	7.0821	2.2198	1.8629	1.1104	15.6294	4.8787	4.1011	2.4801	12.9824	4.0840	3.4235	2.0148
Max.Value (+)	1047.597	62.3257	10.6575	10.1121	2717.681	161.6856	23.6445	20.9744	1704.727	101.4209	19.4631	19.5258
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	99.7569	5.9572	1.8259	1.7091	268.5527	15.8166	4.1037	3.7015	160.6573	9.7152	3.3758	3.2015
Total Units	165	165	165	165	165	165	165	165	165	165	165	165

1996	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	35.8780	6.9492	2.3991	1.7757	90,2821	16,5817	5,5402	4,0543	61,0518	12,2335	4,3005	3,1998
Belgium (+29)	4.5470	3.0596	1.1418	1.0530	10,0487	6,7667	2,5160	2,3165	8,3511	5,6149	2,0981	1,9374
Bulgaria (+3)	253.0313	31.2064	6.1711	8.9134	577,3468	71,2728	13,6606	20,1114	452,8611	55,8387	11,2957	16,0881
France (+22)	4.9713	1.8787	0.9363	0.9912	12,6905	4,8085	2,3834	2,5019	8,2428	3,1054	1,5554	1,6528
Italy (+51)	5.3606	3.3241	1.9988	1.1391	13,9031	8,5413	5,0636	2,7706	8,9186	5,5582	3,3725	1,9638
(-1)	2.8371	2.0676	2.0527	1.0175	5,6739	4,1350	4,1052	2,0350	5,6744	4,1354	4,1056	2,0352
Netherlands (+4)	0.5797	0.4296	0.2244	0.1908	1,3208	0,9790	0,5129	0,4365	1,0331	0,7657	4,1056	0,3391
Romania (+37)	120.0875	18.2122	4.9120	3.5260	308,4062	43,3850	10,8271	7,7768	202,0702	32,2261	9,0755	6,5242
(-1)	74.4297	21.4681	14.0441	5.2538	148,1585	42,7340	27,9560	10,4581	149,5670	43,1402	28,2218	10,5575
Spain (+17)	7.5787	3.7613	2.0143	1.2375	16,9389	8,3646	4,4575	2,7941	13,7507	6,8529	3,6848	2,2267
Max.Value (+)	1214.340	99.9079	16.1014	15.4605	3303,005	271,7494	37,4816	33,3231	1920,351	157,9938	28,2275	28,8419
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Std. Dev. (+)	120.4876	11.6291	2.5832	2.1583	328,0424	29,7528	5,7565	4,7490	194,2203	19,8019	4,7677	3,9986
Total Units	165	165	165	165	165	165	165	165	165	165	165	165

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	83,9103	17,3932	3,8209	2,2358	206,5638	41,5222	8,7021	5,2693	144,8008	30,5211	6,9007	3,9952
Belgium (+29)	5,1879	3,1769	1,5284	1,0456	11,4834	7,0304	3,3769	2,3095	9,5035	5,8206	2,8011	1,9174
Bulgaria (+3)	1386,600	175,5015	1,5284	1,1083	3162,128	409,6829	1,4947	2,4323	2481,360	308,7630	1,0606	2,0362
France (+22)	5,7166	3,3797	1,2474	0,9516	14,6162	8,6383	3,1905	2,4237	9,4481	5,5869	2,0613	1,5754
Italy (+52)	5,7038	3,4096	2,2760	0,9941	14,3418	8,5562	5,6210	2,3627	9,6640	5,7848	3,8937	1,7370
Netherlands (+4)	0,6998	0,4544	0,3311	0,1905	1,5783	8,5562	0,7477	0,4318	1,2574	0,8164	0,5945	0,3410
Romania (+36)	244,6523	52,5621	10,7637	6,5746	624,2638	126,0245	23,7986	15,5475	414,5885	92,3661	19,8296	11,8341
(- 2)	113,7439	52,5621	19,6456	7,8027	220,0662	132,3492	37,9482	15,1295	235,6106	141,6989	40,7634	16,1251
Spain (+17)	7,9114	4,1619	2,4715	1,2185	17,8442	9,3668	5,5175	2,7655	14,2496	7,5106	4,4902	2,1836
Max.Value (+)	2406,567	403,2267	28,0821	18,0596	6793,760	1138,312	68,4906	70,0104	3726,674	624,4141	51,4376	35,1150
Min.Value (+)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Std. Dev. (+)	291,4610	44,5675	5,1931	3,1770	751,0643	115,7023	11,5266	8,3367	489,1872	74,1524	9,5781	5,6904
Total Units	165	165	165	165	165	165	165	165	165	165	165	165

1998	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	139,1104	39,1241	5,8107	2,1465	347,5108	90,9932	13,2071	5,0325	238,7373	69,9691	10,5131	6,0734
Belgium (+29)	5,3903	3,9037	2,1892	1,0782	11,8230	8,5655	4,8159	2,3559	9,9463	7,2009	4,0305	1,9958
Bulgaria (+2)	1446,5504	404,6412	5,9365	13,1420	3156,512	874,8592	12,7776	28,8268	2671,843	753,0442	11,0881	24,1693
(-1)	1620,2918	583,9047	73,1977	30,6327	3219,180	1160,096	145,4286	60,8607	3262,273	1175,625	147,3753	61,6754
France (+22)	5,2639	3,7991	1,7444	0,7729	13,3329	9,6175	4,4440	1,9541	8,7626	6,3260	2,8946	1,2863
Italy (+52)	6,0615	4,3473	3,0070	1,0435	15,3952	11,0426	7,6030	2,4815	10,1988	7,3155	5,0766	1,8232
Netherlands (+4)	0,7856	0,5946	0,4652	0,2401	1,7382	1,3157	1,0317	0,5367	10,1988	1,0855	0,8478	0,4348
Romania (+36)	525,5466	139,2132	17,0185	5,5575	1340,105	326,2903	37,5270	13,1923	10,1988	248,0355	31,3823	10,0331
(- 2)	244,3592	178,1516	29,8051	7,4352	472,8213	344,7128	57,4595	14,5257	506,1153	368,9872	61,9717	15,2427
Spain (+17)	7,8025	5,4075	3,3351	1,0520	17,4248	12,0741	7,4186	2,3648	14,1607	9,8166	6,0734	1,8992
Max.Value (+)	5164,9632	729,1481	49,2503	17,6743	14561,46	2055,670	112,1382	76,3552	8003,982	1352,098	87,8204	27,1198
Min.Value (+)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
Std. Dev. (+)	516,7232	101,7617	8,4495	2,9105	1397,215	246,3516	18,6557	8,0371	838,7201	178,9685	15,5936	5,1511
Total Units	165	165	165	165	165	165	165	165	165	165	165	165

Sector 211 – Manufacturing of Pulp, paper and Paperboard

1995	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	5,7212	1,6188	1,1143	0,2509	12,6163	3.6033	2.5168	0.5654	10.5424	2.9589	2.0143	0.4549
Belgium (+9)	2,5413	1,4513	0,7457	0,2310	5,5860	3.1941	1.6368	0.5039	4.6700	2.6658	1.3721	0.4271
Bulgaria (+4)	9,3149	2,5399	0,7186	0,1961	21,0390	5.7156	1.5849	0.4325	16.7918	4.5892	1.3186	0.3604
France (+33)	2,8424	0,7062	0,5339	0,1982	6,6879	1.6863	1.2520	0.4674	4.9708	1.2231	0.9366	0.3468
Italy (+53)	3,9920	0,7062	1,4222	0,2632	9,1686	3.1352	3.2704	0.6003	7.1344	2.4616	2.5382	0.4732
(- 2)	7,9231	3,0346	2,9406	1,0638	15,7743	6.0386	5.8427	2.1134	15.9189	6.1003	5.9202	2.1420
Netherlands (+6)	1,7550	0,9416	0,6337	0,2832	4,0339	2.1744	1.4449	0.6322	3.1671	1.6908	1.1501	0.5211
Romania (+12)	27,2018	5,1314	1,6900	0,3961	56,8428	10.7550	3.5759	0.8326	52.2016	9.8225	3.2107	0.7575
Spain (+30)	4,6188	1,7141	1,2380	0,2361	10,2402	3.8051	2.7557	0.5276	8.4321	3.1257	2.2541	0.4284
Max.Value (+)	161,3266	24,8906	4,7704	1,3413	339,1501	52.3265	12.1048	2.7194	307.6867	47.4721	7.8732	2.6468
Min.Value (+)	0,0000	0,0000	0,0000	0,0000	0,0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	14,0972	2,2584	0,8378	0,2041	29,5853	4.7544	1.8988	0.4501	26.9530	4.3122	1.5320	0.3830
Total Units	149	149	149	149	149	149	149	149	149	149	149	149

1996	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	5.9134	2.1563	0.4573	0.3092	13.1780	4.8551	1.0255	0.7024	10.7870	3.9063	0.8310	0.5569
Belgium (+9)	1.9769	1.8951	0.2959	0.3484	4.3273	4.1459	0.6393	0.7521	3.6517	3.5025	0.5520	0.6503
Bulgaria (+4)	55.3210	10.2515	0.6954	0.4046	121.7501	22.5557	1.5046	0.8820	101.5957	18.8240	1.2954	0.7491
France (+32)	2.2408	0.8173	0.1832	0.2439	5.3045	1.9837	0.4249	0.5731	3.9130	1.4034	0.3251	0.4294
(-1)	0.1916	0.1916	0.1679	0.1630	0.3654	0.3654	0.3203	0.3108	0.4027	0.4027	0.3530	0.3426
Italy (+54)	2.8475	1.9223	0.5587	0.3676	6.6099	4.4515	1.2865	0.8473	5.0415	3.4076	0.9942	0.6540
(-1)	4.1030	4.1030	2.5091	1.6364	7.8901	7.8901	4.8250	3.1468	8.5482	8.5482	5.2275	3.4092
Netherlands (+6)	1.2715	0.9932	0.1960	0.3033	2.9624	2.3567	0.4359	0.6939	2.2550	1.7402	0.3577	0.5444
Romania (+12)	25.1033	4.6238	1.0025	0.3352	54.3017	9.7317	2.1085	0.7008	46.8443	8.8233	1.9141	0.6437
Spain (+30)	3.1954	2.2505	0.4181	0.2402	7.1717	5.0462	0.9333	0.5427	5.7776	4.0725	0.7602	0.4324
Max.Value (+)	129.7959	18.4312	3.2237	1.4872	293.6517	41.6991	6.8600	3.1706	232.6117	33.0313	6.0816	2.8010
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	15.6526	2.3338	0.4386	0.2563	34.8890	5.1154	0.9487	0.5764	28.4692	4.3225	0.8245	0.4706
Total Units	149	149	149	149	149	149	149	149	149	149	149	149

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	24.1860	2.5978	1.1303	0.2958	56.1372	5.9658	2.5456	0.6741	42.7927	4.6340	2.0469	0.5312
Belgium (+9)	4.2086	1.6738	0.7276	0.2734	9.4668	3.7570	1.6323	0.6023	7.5984	3.0276	1.3169	0.5017
Bulgaria (+4)	407.8738	25.6663	1.9954	0.0416	995.5171	62.3001	4.8716	0.0965	692.3077	43.7369	3.3860	0.0732
France (+32)	4.8548	0.8118	0.4746	0.2301	11.5948	1.9604	1.1160	0.5501	8.4451	1.4001	0.8322	0.4006
(-1)	0.2900	0.1818	0.1613	0.1194	0.5755	0.3609	0.3201	0.2370	0.5845	0.3665	0.3251	0.2406
Italy (+55)	5.6633	1.8604	1.2025	0.3746	12.9670	4.2535	2.7483	0.8556	10.1307	3.3280	2.1538	0.6709
Netherlands (+6)	2.9329	0.8418	0.5772	0.2580	6.5749	1.9615	1.2695	0.5688	5.3685	1.4925	1.0696	0.4772
Romania (+8)	141.7509	7.0295	4.1271	0.3381	306.9571	14.7834	8.7194	0.7139	264.0308	13.4123	7.8454	0.6427
(-4)	93.2505	10.0437	3.4990	0.6670	180.9263	19.4575	6.8460	1.2973	192.6357	20.7811	7.1624	1.3743
Spain (+30)	6.4989	2.2256	1.0141	0.2584	14.5723	4.9782	2.2715	0.5829	11.7547	4.0335	1.8361	0.4653
Max.Value (+)	917.9226	46.6631	12.9609	1.7266	2311.109	117.4866	26.9625	3.7797	1522.710	77.4079	24.9585	3.1788
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	96.7021	5.1918	1.3670	0.2509	233.6144	12.4056	2.9260	0.5741	166.2854	9.0277	2.5883	0.4537
Total Units	149	149	149	149	149	149	149	149	149	149	149	149

1998	**Input – Output Orientation**				**Input - Orientation**				**Output – Orientation**			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	29.5149	29.5149	1.9136	29.5149	64.9205	64.9205	4.3062	64.9205	54.3321	54.3321	3.4390	54.3321
Belgium (+9)	3.9667	3.9667	1.2824	3.9667	8.7832	8.7832	2.8495	8.7832	7.2497	7.2497	2.3377	7.2497
Bulgaria (+4)	406.8135	406.8135	2.7879	406.8135	892.7596	892.7596	5.8089	892.7596	749.3734	749.3734	5.3623	749.3734
France (+32)	4.3006	4.3006	0.8985	4.3006	10.2693	10.2693	2.1195	10.2693	7.4792	7.4792	1.5717	7.4792
(-1)	0.3421	0.3421	0.2624	0.3421	0.6601	0.6601	0.5062	0.6601	0.7102	0.7102	0.5446	0.7102
Italy (+55)	5.1328	5.1328	2.0576	5.1328	11.9882	11.9882	4.8272	11.9882	9.0308	9.0308	3.6087	9.0308
Netherlands (+6)	2.5207	2.5207	0.9848	2.5207	5.7888	5.7888	2.1909	5.7888	4.5244	4.5244	1.8018	4.5244
Romania (+8)	246.7993	246.7993	7.2278	246.7993	534.6813	534.6813	14.9116	534.6813	459.5292	459.5292	13.4286	459.5292
(-4)	162.2992	162.2992	5.2810	162.2992	314.9060	314.9060	10.9935	314.9060	335.2695	335.2695	11.4793	335.2695
Spain (+17)	5.9249	5.9249	1.5738	5.9249	13.2770	13.2770	3.5149	13.2770	10.7226	10.7226	2.8572	10.7226
Max.Value (+)	873.3962	873.3962	20.9341	873.3962	1987.525	1987.525	43.5735	1987.5257	1558.075	1558.075	40.2913	1558.0752
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	118.6132	118.6132	2.2550	118.6132	262.7150	262.7150	4.7922	262.7150	216.9641	216.9641	4.2626	216.9641
Total Units	149	149	149	149	149	149	149	149	149	149	149	149

Sector – 241 Manufacturing of Basic Chemicals

1995	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	28.4051	7.2562	1.6249	0.6058	64.4586	16.3200	3.6467	1.3842	51.2877	13.1771	2.9564	1.0883
Belgium (+37)	9.6769	4.3116	0.7910	0.6727	22.5636	10.0513	1.8406	1.5725	17.0165	7.5852	1.3933	1.1812
(-1)	38.2586	22.3667	9.9145	0.4629	74.3475	43.4651	19.2668	0.8996	78.8172	46.0782	20.4251	0.9537
Bulgaria (+6)	37.2029	11.1360	2.3215	0.5085	81.8109	25.3500	5.2452	1.0950	68.7390	20.0445	4.2046	0.9531
(-1)	384.0220	125.9347	30.5593	3.4107	650.4337	213.3006	51.7595	5.7768	937.5747	307.4645	74.6094	8.3271
France (+62)	10.7853	3.4651	0.7647	0.5129	25.0468	8.0792	1.7794	1.2226	19.0496	6.1078	1.3510	0.8950
Italy (+90)	14.2803	6.3362	1.3356	0.5371	32.4867	14.3567	3.0209	1.2258	25.7038	11.4339	2.4141	0.9642
(-3)	26.2144	13.7608	2.1475	0.4182	51.0898	26.7946	4.1929	0.8160	53.9453	28.3453	4.4097	0.8594
Netherlands (+8)	8.5175	4.4093	0.6105	0.4747	19.5718	10.1395	1.4113	1.1122	15.1401	7.8339	1.0798	0.8299
Romania (+53)	92.4919	15.1697	3.9340	0.8964	208.5879	33.1497	8.6314	1.9618	168.0411	28.2039	7.2895	1.6647
(-4)	149.7002	33.9073	10.2713	2.3897	285.9638	64.5781	19.5269	4.5519	316.2239	71.8331	21.8033	5.0583
Spain (+19)	16.1059	7.6183	1.1926	0.3799	37.4711	17.5226	2.7526	0.8897	28.4399	13.5558	2.1171	0.6691
Max.Value (+)	850.1355	129.8327	30.8148	4.9747	2197.075	262.6113	64.6822	12.5133	1386.707	256.7850	58.8521	9.5892
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	72.5113	10.9331	2.4903	0.6640	172.9748	23.6879	5.4004	1.5262	127.3321	20.6712	4.6793	1.2037
Total Units	284	284	284	284	284	284	284	284	284	284	284	284

1996	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	42.4997	6.1133	2.4994	0.6055	94.1061	13.5659	5.5932	1.3877	78.4368	11.2423	4.5625	1.0849
Belgium (+37)	7.8997	2.4832	0.9754	0.5495	19.8917	5.9168	2.3112	1.3051	13.6674	4.3126	1.6990	0.9554
(-1)	29.4133	14.8389	12.3262	0.6896	56.3478	28.4272	23.6135	1.3211	61.5337	31.0435	25.7868	1.4427
Bulgaria (+7)	610.3990	57.8169	13.2107	1.3981	1267.281	120.4647	27.7963	2.9826	1184.645	111.9046	25.3839	2.6443
France (+62)	8.7318	1.7506	0.9223	0.4907	20.4940	4.1081	2.1962	1.1916	15.3229	3.0767	1.6067	0.8437
Italy (+91)	11.0319	3.2487	1.9152	0.5510	25.6029	7.4493	4.3969	1.2726	19.5602	5.8053	3.4218	0.9793
(-2)	10.3525	4.2251	2.2854	0.9916	20.6226	8.4153	4.5498	1.9728	20.7884	8.4854	4.5923	1.9938
Netherlands (+8)	5.9757	1.9951	0.5928	0.3787	13.7835	4.6595	1.3755	0.8867	10.6172	3.5133	1.0477	0.6640
Romania (+52)	102.4419	13.7056	5.7262	0.8742	233.7846	30.3778	12.5643	1.8963	184.7178	25.1871	10.5922	1.6299
(-5)	299.8569	68.3670	18.7094	3.9346	554.5099	126.0224	198.4569	7.2213	653.6318	149.5542	40.8323	8.6596
Spain (+19)	12.8835	3.0448	1.4375	0.4184	30.1559	6.9735	3.3162	0.9715	22.6364	5.4271	2.5535	0.7410
Max.Value (+)	3008.205	277.2727	58.2197	7.5743	6040.968	556.8089	116.9147	16.3462	5992.053	552.3003	115.9680	14.1146
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	198.5890	19.5583	4.5546	0.6996	413.7015	40.5565	9.5506	1.5515	387.4615	38.1165	8.7979	1.2913
Total Units	284	284	284	284	284	284	284	284	284	284	284	284

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	131.5051	11.1241	3.6183	0.6220	296.4361	24.9453	8.1125	1.4208	239.8350	20.3194	6.6014	1.1176
Belgium (+37)	8.5811	2.2068	0.8671	0.4462	20.6102	5.2857	2.0809	1.0767	14.8141	3.8183	1.4965	0.7675
(-1)	40.8635	19.6670	13.9955	0.7861	70.8175	34.0835	24.2546	1.3624	96.6096	46.4969	33.0882	1.8586
Bulgaria (+7)	2610.093	155.8824	8.0052	0.4563	5657.820	338.3337	17.5528	0.9868	4851.020	289.4573	14.7392	0.8502
France (+62)	9.8914	1.5815	0.8045	0.4193	23.2055	3.7111	1.8988	1.0144	17.3634	2.7802	1.4082	0.7220
Italy (+93)	12.7062	2.9417	1.6508	0.5344	28.9710	6.6425	3.7449	1.2205	22.8231	5.3154	2.9715	0.9567
Netherlands (+8)	7.3836	1.7504	0.6048	0.3334	17.0463	4.0969	1.4140	0.7884	13.0648	3.0638	1.0596	0.5786
Romania (+49)	315.6532	29.5930	13.8085	1.3245	740.4791	67.3004	30.6581	2.8984	565.3207	53.8761	25.4263	2.4601
(- 8)	444.2713	37.2597	23.3701	3.4290	822.2626	68.5755	43.2716	6.2501	971.9542	82.1993	51.1176	7.6713
Spain (+19)	13.4066	2.6644	1.1611	0.4258	31.5643	6.1950	2.7109	1.0130	23.4232	4.6953	2.0426	0.7413
Max.Value (+)	12138.48	643.6830	85.7352	11.0414	26106.31	1384.373	181.7439	22.7597	22687.21	1203.067	162.2961	21.4450
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	786.1234	46.4889	8.5573	0.9699	1727.207	102.0644	18.7648	2.1017	1458.998	86.3124	15.9932	1.8195
Total Units	284	284	284	284	284	284	284	284	284	284	284	284

1998	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	203.4873	19.8966	2.8943	1.2619	469.2631	45.5070	6.4996	2.9136	366.6303	35.9856	5.2711	2.2612
Belgium (+37)	8.8143	2.6390	0.9127	0.6468	21.7031	6.4039	2.2237	1.5895	15.0436	4.5353	1.5630	1.1032
(-1)	53.3098	29.4606	20.1884	1.8157	79.1205	43.7243	29.9629	2.6948	163.4169	90.3090	61.8860	5.5660
Bulgaria (+6)	3989.128	299.3463	4.2591	5.1717	8984.106	676.9923	9.9610	13.1827	7259.575	543.9174	7.7621	9.0104
(-1)	205.9170	27.5988	3.0579	3.2745	401.5157	53.8148	5.9625	6.3849	422.6964	56.6536	6.2770	6.7218
France (+62)	9.7505	1.7651	0.7531	0.6049	23.0149	4.1555	1.7943	1.4623	17.0387	3.0923	1.3099	1.0403
Italy (+92)	11.9659	3.1162	1.4854	1.0137	27.8564	7.2244	3.4415	2.3726	21.1586	5.5270	2.6345	1.7852
(-1)	22.5402	7.6710	4.3692	1.2340	43.9428	14.9548	8.5178	2.4058	46.2785	15.7497	8.9706	2.5336
Netherlands (+8)	7.2142	1.7121	0.6319	0.5226	16.7122	3.9235	1.4875	1.2224	12.7557	3.0539	1.1026	0.9167
Romania (+49)	597.7710	62.6559	10.6942	2.8442	1402.531	143.6094	23.4741	6.1824	1070.486	113.5746	19.7855	5.2985
(-8)	841.2638	77.3496	21.5975	8.7756	1557.179	142.3428	40.0872	15.8883	1840.315	170.5689	47.1504	19.7623
Spain (+19)	12.4864	3.0576	0.9684	0.8021	29.1442	7.0510	2.2284	1.8865	21.9546	5.4196	1.7214	1.4061
Max.Value (+)	18108.43	1327.466	43.1331	26.0499	39715.45	2911.402	91.3851	53.7364	33284.76	2439.991	81.6903	50.5599
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	1185.762	93.8744	5.8359	2.3024	2685.113	211.6080	12.6318	5.1925	2158.653	171.3173	10.9425	4.2918
Total Units	284	284	284	284	284	284	284	284	284	284	284	284

Sector 251 – Manufacturing of Rubber Products

1995	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	51.9853	13.6519	2.4761	14.8249	123.5467	31.0746	5.4985	32.5439	91.6944	24.7469	4.5433	27.4493
Belgium (+4)	10.4517	4.0200	1.1821	4.3802	24.0843	9.1738	2.6318	10.0879	18.5023	7.1741	2.1511	7.7576
Bulgaria (+2)	86.8436	28.9284	3.8911	36.0284	185.0707	61.6379	8.2729	76.7787	163.6238	54.5131	7.3465	67.8822
France (+40)	10.1427	3.5265	0.9440	4.1635	23.5852	8.1911	2.1957	9.6724	17.8768	6.2200	1.6648	7.3424
(-1)	10.5483	3.4659	0.6044	4.4554	21.0565	6.9186	1.2066	8.8938	21.1369	6.9450	1.2112	8.9277
Italy (+41)	10.3535	3.7908	1.9375	4.3101	23.7208	8.6420	4.3775	9.8661	18.5007	6.7987	3.4966	7.7067
(-2)	7.5801	3.3096	2.1785	3.1680	14.5985	6.3621	4.1958	6.1015	15.7740	6.9007	4.5330	6.5922
Netherlands (+3)	2.8135	1.4148	0.6434	1.2098	6.7410	3.3841	1.5344	2.8973	4.8302	2.4319	1.1084	2.0777
Romania (+29)	198.1837	47.8871	5.7689	51.0902	475.2489	109.1015	12.5664	110.7881	348.3112	87.0441	10.7800	95.5879
(-2)	68.3236	22.4089	5.4917	28.2964	131.3342	43.0892	10.6423	54.3918	142.5614	46.7421	11.3620	59.0430
Spain (+15)	10.9708	4.3975	2.1910	4.5639	24.6916	9.8647	4.8927	10.2684	19.7787	7.9488	3.9740	8.2304
Max.Value (+)	1411.134	240.0086	20.8767	227.4498	4036.770	686.5820	45.8296	478.0996	2169.541	369.0000	38.3431	434.0014
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	167.4657	34.8670	3.3922	36.9333	443.0644	84.0977	7.5010	79.9098	277.1459	61.8783	6.3176	69.4081
Total Units	139	139	139	139	139	139	139	139	139	139	139	139

1996	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	73.6176	3.7069	2.9541	17.0474	166.4966	8.3647	6.6676	37.8170	133.5201	6.7294	5.3578	31.3466
Belgium (+4)	12.6782	1.9214	1.1623	4.0958	29.8774	4.3964	2.6239	9.6421	22.0961	3.4259	2.0928	7.1443
Bulgaria (+2)	651.6341	22.6273	3.8342	206.8824	1370.982	47.3294	7.7337	435.2598	1242.071	43.3751	7.6041	394.3388
France (+41)	12.0525	1.2574	0.7954	3.8475	28.0607	2.9600	1.8593	8.9537	21.2234	2.1980	1.3970	6.7769
Italy (+43)	11.7486	1.8860	1.8764	3.7893	27.3765	4.3194	4.2935	8.8196	20.7450	3.3699	3.3532	6.6966
Netherlands (+3)	3.8843	1.0626	0.5256	1.3094	8.8555	2.4243	1.1996	2.9857	6.9193	1.8919	0.9354	2.3323
Romania (+29)	259.1435	9.7283	8.5960	52.2330	590.5746	21.9320	19.2970	116.0853	467.8923	17.7264	15.6915	96.0765
(-2)	722.3384	16.4964	19.9495	229.1866	1404.680	32.1022	38.7992	445.6843	1487.046	33.9350	41.0639	471.8147
Spain (+15)	13.6983	2.4635	1.8823	4.3985	31.1769	5.5545	4.2289	10.0042	24.5269	4.4473	3.4080	7.8802
Max.Value (+)	1379.271	37.5239	36.6532	399.1730	3591.736	96.7819	95.4480	841.0873	2393.422	71.4186	59.5032	759.7386
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	221.5856	6.5239	5.3317	48.0821	513.1589	15.2398	12.5094	107.2620	398.1854	11.7069	9.5025	88.8073
Total Units	139	139	139	139	139	139	139	139	139	139	139	139

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	169.8670	3.0573	5.0061	21.6427	374.5386	6.7664	11.1034	47.1423	312.9041	5.6164	9.1825	40.2745
Belgium (+4)	11.3626	2.3434	1.1840	3.5596	27.7670	5.4687	2.8090	8.6849	19.3563	4.1317	2.0622	6.0715
Bulgaria (+2)	2311.038	33.7547	8.9734	15.7869	4876.235	70.8414	18.4146	32.3967	4393.405	64.4942	17.5023	30.7917
France (+41)	11.8446	1.3500	0.8835	3.6599	27.5799	3.1868	2.0590	8.5159	20.8388	2.3524	1.5538	6.4419
Italy (+43)	11.2459	2.1078	1.6675	3.5251	25.9275	4.8112	3.8017	8.1203	19.9916	3.7752	2.9867	6.2705
Netherlands (+3)	3.7239	1.1553	0.5653	1.1916	8.8454	2.7311	1.3272	2.8290	6.4325	2.0030	0.9851	2.0592
Romania (+28)	616.7278	5.4813	18.7033	90.4890	1370.993	11.7996	41.2463	195.5076	1129.280	10.2973	34.4741	169.4574
(-3)	145.5583	7.8373	12.7928	45.2439	283.3988	5.3694	24.8737	88.0870	299.4023	16.1833	26.3524	93.0652
Spain (+15)	12.3755	2.3992	1.6554	3.9128	27.5805	15.2044	3.6821	8.7194	22.5028	4.3468	3.0138	7.1150
Max.Value (+)	4397.049	51.7166	63.3147	492.1741	9290.686	109.2738	143.0143	1050.211	8347.904	98.1851	113.6128	926.2590
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	553.9519	5.3755	10.6916	57.8965	1212.377	11.3747	23.8558	123.9937	1026.963	10.2230	19.5800	109.2001
Total Units	139	139	139	139	139	139	139	139	139	139	139	139

1998	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	243.6124	27.9773	4.1210	28.7330	541.0109	61.6078	9.1087	62.0348	446.3468	51.5878	7.5793	53.8262
Belgium (+4)	10.8730	3.9560	1.4095	4.2500	25.6196	9.2446	3.2570	10.0037	18.9369	6.9370	2.4934	7.4081
Bulgaria (+1)	1825.105	334.1574	0.0000	344.5330	3863.542	707.3733	0.0000	729.3373	3459.206	633.3438	0.0000	653.0092
(-1)	279.6877	86.7771	4.9081	107.7773	509.4320	158.0586	8.9398	196.3089	620.1761	192.4185	10.8832	238.9840
France (+41)	10.6071	3.3777	1.0821	4.0879	24.6588	7.8577	2.5266	9.4997	18.7087	5.9544	1.9029	7.2117
Italy (+43)	9.8321	3.3300	1.9150	3.8688	22.6692	7.6511	4.3883	8.9172	17.4647	5.9316	3.4148	6.8735
Netherlands (+3)	3.3795	1.4717	0.7235	1.3736	8.1229	3.5169	1.7101	3.2969	5.7890	2.5323	1.2551	2.3556
Romania (+28)	1070.277	109.7666	13.9648	110.9794	2380.085	241.3452	30.3303	237.8128	1959.247	202.7169	26.0549	209.1862
(-3)	252.5199	77.6921	24.2601	96.9406	491.6670	151.2645	47.1824	188.7454	519.3968	159.8077	49.9606	199.3949
Spain (+15)	12.2335	4.4935	2.0533	4.7945	27.8597	10.2218	4.6654	10.9181	21.8351	8.0272	3.6713	8.5579
Max.Value (+)	4428.679	572.6147	42.2434	491.8681	10017.71	1221.324	87.2121	1049.1007	7937.909	1078.060	81.9265	926.0391
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	740.3917	80.1538	6.7250	70.9761	1661.419	174.6148	14.4807	150.3262	1347.072	149.1984	12.6873	135.0578
Total Units	139	139	139	139	139	139	139	139	139	139	139	139

Sector 252 – Manufacturing of Plastic Products

1995	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	21.2251	2.8702	2.3726	0.8019	49.5345	6.5752	5.4271	1.8229	37.7067	5.1511	4.2597	1.4426
Belgium (+49)	8.2171	2.3935	1.4039	1.0072	18.1910	5.3074	3.1125	2.2311	15.0155	4.3694	2.5631	1.8407
Bulgaria (+6)	79.8411	8.7677	5.9460	1.1983	178.5133	20.1562	13.5715	2.7477	144.9584	15.5833	10.6326	2.1353
(-1)	90.0170	20.6876	19.5811	3.1964	179.7240	41.3040	39.0947	6.3817	180.3448	41.4467	39.2298	6.4037
France (+105)	7.8016	1.2765	1.1313	0.6440	18.5578	3.0532	2.6798	1.5517	13.5771	2.2121	1.9726	1.1089
Italy (+171)	6.4418	1.6504	1.6293	0.6202	14.8607	3.7943	3.7404	1.4275	11.4437	2.9406	2.9050	1.1033
(-2)	2.9682	1.0681	1.1421	0.4637	5.7572	2.0605	2.2096	0.8933	6.1300	2.2187	2.3652	0.9644
Netherlands (+8)	3.1325	1.2472	0.7131	0.4412	7.3708	2.9537	1.6841	1.0413	5.4546	2.1610	1.2381	0.7664
Romania (+70)	92.4888	8.0215	6.6891	1.1906	217.4372	18.3600	15.2507	2.5613	164.0951	14.5010	12.1098	2.2355
(-4)	56.3613	6.9074	7.7027	2.8445	106.5352	12.9810	14.4992	5.3641	120.2933	14.8470	16.5235	6.0884
Spain (+58)	10.5251	3.1516	2.2792	0.9894	24.1530	7.0925	5.1472	2.2557	18.8060	5.6982	4.1105	1.7751
Max.Value (+)	897.2722	53.1753	40.4558	14.6418	2566.786	152.1163	115.7302	32.7192	1379.506	92.8873	62.1986	26.5011
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	66.2614	5.1198	3.5315	0.9032	172.5171	12.4427	8.7601	2.0325	110.0971	8.9735	6.1019	1.6481
Total Units	474	474	474	474	474	474	474	474	474	474	474	474

1996	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	36.8553	13.0159	2.7922	0.9427	80.7686	29.9572	6.4225	2.1546	62.7329	23.2691	4.9937	1.6891
Belgium (+49)	9.5121	5.3617	1.0475	1.1534	21.3503	12.0424	2.3511	2.5820	17.2072	9.6937	1.8956	2.0918
Bulgaria (+7)	678.1244	217.8502	31.4801	2.3674	1591.802	515.7134	76.2189	5.7641	1199.856	383.6569	54.6895	4.0984
France (+105)	7.2842	3.1790	0.6975	0.7278	17.5655	7.6673	1.6616	1.7496	12.5543	5.4771	1.2103	1.2553
Italy (+170)	6.7081	3.9121	1.1265	0.7358	15.7026	9.1157	2.6196	1.7139	11.7839	6.8959	1.9880	1.2965
(-3)	9.6083	5.3989	1.2354	1.1770	19.1423	10.7605	2.4623	2.3451	19.2917	10.8356	2.4794	2.3631
Netherlands (+8)	3.3050	2.4491	0.4708	0.4084	7.7910	5.7952	1.1204	0.9648	5.7597	4.2566	0.8146	0.7104
Romania (+70)	130.9673	41.9606	9.7695	1.5202	282.6868	94.9368	22.0547	3.3129	224.7692	75.8674	17.6989	2.8207
(-4)	229.5264	108.1248	19.9233	6.1990	465.4096	205.0456	38.1138	11.5974	509.5567	229.5264	41.9053	13.3547
Spain (+58)	9.0111	5.7768	1.3775	0.9651	20.1024	12.8151	3.0689	2.1492	16.4262	10.5848	2.5147	1.7633
Max.Value (+)	1223.879	378.5347	77.1674	15.6709	2697.615	834.3482	170.0886	33.8194	2240.261	692.8926	141.2518	29.2024
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	119.6581	37.6201	7.2210	0.9809	276.9738	88.9601	17.2306	2.1632	209.4611	66.6197	12.7399	1.8199
Total Units	474	474	474	474	474	474	474	474	474	474	474	474

1997	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	77.4951	6.0881	4.3206	0.8692	171.1585	13.6295	9.6758	1.9611	142.6656	11.0927	7.8760	1.5733
Belgium (+49)	9.0268	3.7203	1.6539	0.8994	20.2445	8.3273	3.7071	2.0080	16.3365	6.7446	2.9945	1.6343
Bulgaria (+6)	2359.070	67.0092	9.2528	0.2004	5087.412	144.0963	19.7610	0.4431	4405.689	125.4778	17.4229	0.3663
(-1)	5179.666	324.9044	75.5826	0.6554	10239.53	642.2940	149.4171	1.2956	10481.97	657.5015	152.9548	1.3263
France (+105)	6.9489	1.8184	1.1697	0.5674	16.8921	4.4091	2.7989	1.3694	11.9274	3.1243	2.0241	0.9757
Italy (+171)	6.4974	3.1373	2.2138	0.6349	15.1027	7.2322	5.1351	1.4643	11.4975	5.5851	3.9231	1.1289
(-2)	4.7990	3.3935	2.2171	0.8521	9.5524	6.7547	4.4129	1.6960	9.6442	6.8197	4.4558	1.7125
Netherlands (+8)	2.9953	1.7335	0.9091	0.3251	7.1288	4.1776	2.1993	0.7839	5.1742	2.9671	1.5525	0.5569
Romania (+70)	274.2662	18.2324	17.7270	2.0352	611.5946	40.2611	39.0530	4.4013	502.4206	33.6129	32.7497	3.8070
(-4)	157.8675	11.6588	14.7555	2.7557	309.1668	22.8080	28.8514	5.3804	322.6853	23.8599	30.2147	5.6511
Spain (+57)	7.9420	4.1256	2.2329	0.8166	17.8690	9.2521	5.0074	1.8294	14.3552	7.4755	4.0467	1.4810
(-1)	11.5305	6.9315	4.6248	1.5499	22.4633	13.5036	9.0098	3.0195	23.6915	14.2419	9.5024	3.1846
Max.Value (+)	4864.871	213.1901	86.2471	14.5514	10267.33	472.4117	174.7343	31.9775	9245.647	388.5228	170.3107	28.2624
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	351.6525	16.0488	8.9239	1.2309	758.7135	34.7899	19.3618	2.6184	659.3110	29.9613	16.7974	2.3381
Total Units	474	474	474	474	474	474	474	474	474	474	474	474

1998	Input – Output Orientation				Input - Orientation				Output – Orientation			
	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA	NPE	NPE-CC	NPE-I	NPE-FA
Global Mean (+)	114.3908	8.1375	5.3296	1.7895	254.0056	18.1481	11.9605	3.9985	209.8951	14.8791	9.6985	3.2679
Belgium (+49)	8.8378	3.1162	2.4398	0.7283	19.9607	7.0211	5.5023	1.6412	15.9082	5.6203	4.3971	1.3139
Bulgaria (+6)	2376.476	105.6960	2.5382	3.8212	5157.225	227.8587	5.6492	8.3898	4416.813	197.5401	4.6118	7.0195
(-1)	2100.970	108.6383	97.8066	14.4329	4174.188	215.8416	194.3212	28.6751	4230.065	218.7309	196.9224	29.0589
France (+105)	6.7606	1.5990	1.9222	0.5011	16.5811	3.9212	4.6606	1.2171	11.5430	2.7313	3.3019	0.8588
Italy (+172)	6.2576	2.5200	2.6879	0.6844	14.7587	5.8915	6.3172	1.5987	10.9513	4.4358	4.7394	1.2049
(-1)	9.1793	4.2498	4.4852	0.7278	18.2942	8.4698	8.9390	1.4505	18.4235	8.5296	8.5296	1.4607
Netherlands (+8)	3.0856	1.2561	1.2958	0.5324	7.3758	3.0195	3.1233	1.2994	5.3133	2.1555	2.2191	0.9045
Romania (+70)	521.3248	31.9292	21.8778	7.8398	1162.857	70.4871	47.7756	17.1527	954.8141	58.8888	40.6501	14.5562
(-4)	300.0189	17.7203	30.1530	9.6644	587.7762	34.6753	58.9691	18.8951	613.0037	36.2543	61.7329	19.7910
Spain (+57)	7.4556	2.9281	2.5999	0.9422	16.8534	6.6786	5.9093	2.1528	13.4300	5.2400	4.6644	1.6846
(-1)	36.2163	28.4461	22.0166	10.8048	49.5254	38.8997	30.1074	14.7754	134.7673	105.8529	81.9274	40.2064
Max.Value (+)	3901.163	277.9045	112.9007	61.8690	8455.743	615.5794	229.0043	127.6250	7419.087	506.6183	222.6869	120.0807
Min.Value (+)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. (+)	420.0282	24.6379	10.8907	4.6367	928.1734	53.4711	23.2073	9.9475	777.3463	46.0227	20.6708	8.7681
Total Units	474	474	474	474	474	474	474	474	474	474	474	474

General Conclusions

In this dissertation we have analysed a sample data set of 1379 firms covering a time period of four years, from 1995 to 1998. The firms belong to six manufacturing industries – textile weaving (more than 12%); other textiles (about 12%); pulp, paper and paperboard (about 11%); basic chemicals (about 21%); rubber products (10%); plastic products (more than 34%) – and, for each firm, we disposed of annual balance sheet, and profit and loss accounting information, in thousands of dollars expressed in constant prices of 1995. The database also pooled together seven European countries: Belgium Bulgaria, France, Italy, the Netherlands, Romania, and Spain.

The ranking of the firms' distribution per countries gives the first position to Italy (34%), followed by France (21%), Romania (19%), Belgium and Spain with 11% each, and finally Bulgaria and the Netherlands, each with about 2%. The firms are grouped according to the three main categories of ownership forms present in the database. Overall, across countries and sectors, the bulk of the firms (85.5%) are *public* (SA or assimilated), 10% are private (Ltd. type), and the remaining 4.5% form a third category, named *other types*. The differences between the three types of ownership are underlined by the legal aspects characteristic to each one like i.e. the selling of the shares and debts' liability.

The breakdown of the ownership forms per countries, allows us to identify three main patterns. The first includes Belgium, Bulgaria, Romania, and Spain where almost all firms (more than 95%) are public and the rest are private. The second pattern distinguishes France, where firms are distributed among public (more than 75%), and other type of ownership (about 20%). The third pattern, is common to Italy and the Netherlands, where most of the firms are public (about 80% and 55% respectively) and the rest private. Overall, the public firms are the dominant ownership type, followed by the private, and in the last place fall the other type firms. We based our empirical analysis in this data set.

The general conceptual framework is defined by the non-parametric frontier methodology, DEA, and we work in turn with VRS and CRS, and with both input-output, input, and/or output orientations. Hereafter, we summarise the main results obtained in each of the chapters of this dissertation.

In **Chapter 2**, we take up the issue of firms' efficiency in productivity analysing the growth in output and its main contributing factors. The starting point of this approach is the construction of a best practice production frontier allowing for the measurement of technical change (shifts in the frontier). Technical efficiency is then calculated, for each observation unit, as the distance between the frontier and the observed output (catching up effect). Total factor productivity growth (TFP) measure is finally obtained by summing up temporal changes in efficiency and technical change.

An important contribution of the methodology applied in this chapter is that it allows us not only to distinguish the contribution of the above mentioned factors to TFP, but it offers an important added dimension to measure technical change, that is with final and initial year data respectively. Moreover, for each case – final and initial year data - the output growth rate can be broken down in three main components: technical efficiency change ($\dot{CTE}$), or the so-called catching up effect; technical change ($\dot{TC}$); and variation in inputs' usage ($\dot{I}$).

Another contribution of this chapter is related to the measurement of scale effects. That is, we identify the presence of scale effects taking as reference the variation in inputs. The intuition is as follows: input changes calculated relative to the variable returns to scale (VRS) technology can be decomposed into input changes calculated relative to the CRS technology and a scale effects component (captures changes in the deviation between the VRS and CRS technology). In the line with the methodology applied to measure technical change, we determine scale effects both with final and initial year data. Most of the cases that calculate scale efficiency identifying deviations from returns to scale, take as reference the technical efficiency change component rather than input changes.

We specify one output (turnover), and three inputs: number of employees, fixed assets, and material expenses. For each industry sector and across countries, we construct a best-practice frontier and compare each firm in that sector with the best-practice frontier. The frontier is defined such that gives the maximum feasible output with the given set of inputs.

We performed the calculations with VRS, CRS technology and *output* orientation. We report the results per sector, for the initial and final years of the time period – 1995 and 1998 – and separately for the positive and negative output growth cases. The main findings are presented hereafter:

1. *CRS setting. The decomposition with initial years' data*:

   1.1. *The positive growth in output* is, in average, explained as follows: in sectors 175, 211, 251, and 252 – other textiles; pulp, paper and paperboard; rubber products; and plastic products – all factors exhibit positive sign, but the dominant factor in magnitude is the variation in inputs' usage, followed by technical efficiency change (catching up), and in the last place comes the technical change (shift in the frontier). The only exception is sector 252, where the catching up effect is greater than the variation in inputs' usage.

   The two remaining sectors with positive output growth rates – 172 (textile weaving) and 241 (basic chemicals) – differ with respect to the others in the sign of the technical change effect which is negative. In other words, on average, in these two sectors, the frontier is shifting downwards which could somehow be assimilated with a technological amnesia. Firms do not invest in technology but they are rather facing the problem of an obsolete capital endowment. Apart from this, another different aspect comes from the fact that in absolute terms, the catching up effect dominates the variation in inputs. In other words, the output fall is due, in the first place to the fact that firms are not getting closer to the efficient frontier. Their performance in technical efficiency is worsening over time.

1.2. For *the negative growth in output,* the picture is somehow the opposite of the positive output growth case: in two of the sectors – 172 (textile weaving) and 211 (pulp, paper and paperboard) – all effects have negative sign, the most negative being the inputs' usage and the catching up effects. In other words, the decrease in output is explained by the fact that all effects work in the same direction: firms are diminishing the inputs used in the production process and the frontier is shifting downwards.

In the rest of the sectors – 175, 241, 251, and 252 – the distinction is made again by the technical change effect which this time is positive. In other words, in these four sectors, the frontier is shifting upwards but this effect is not enough in order to compensate the magnitude of the other two effects: catching up and the decrease in inputs.

2. ***CRS setting***. *The decomposition with final years' data:* we recall here that with the methodology applied in Chapter 2, the catching up effect is independent of the decomposition being performed with initial or final years' data. On the other hand, the technical change and the variation in inputs' usage do vary when switch from initial to final year framework. As the growth rate of output is the same as before, we can again distinguish between positive and negative growth rates.

2.1. For the *positive output growth rates* we find again sectors where all effects exhibit a positive sign, like 175 (other textiles), and 252 (plastic products), and sectors were the technical change effect is negative. These sectors are: 172 (textile weaving), 211 (pulp, paper and paperboard), 241 (basic chemicals), and 251 (rubber products). The sectors were all effects are positive, have as common feature the fact that technical change is the smallest effect, while catching up and inputs' usage vary in magnitude from one sector to another. In the rest of the sectors, were technical change is negative, the dominant factor is everywhere the variation in inputs.

2.2. The case of the *negative output growth*, is somehow the opposite of the positive growth in output. We distinguish again two situations: (a) sectors were all effects are negative – 172, 211, 241, and 251. They all have in common the fact that the technical change effect is the smallest in magnitude, while the other two effects alternate in influence among sectors. The second situation, (b), corresponds to the sectors with the technical change effect positive - 175 and 252 – where the catching up effect is more negative than the variation in inputs.

The general conclusion, for the **CRS** setting, is that independent of the type of decomposition – with initial or final year's data – the *growth in output* is explained by the catching up and variation in inputs' usage effects. The shifts in the frontier, in some cases reinforce the previous effects or on the contrary, move in the opposite direction. Whatever the direction of the movements, technical change is always smaller in magnitude.

For the *negative growth rate of output*, we have found basically a situation similar to the previous one: the fall in output is again explained by the catching up and inputs' usage, this time both with negative sign, while the technical change sometimes is positive and others negative. Nevertheless, independent of its sign, never overlaps in magnitude the other two effects.

3. *VRS setting.*

For this case we have to say that the empirical evidence shows results very similar to the ones already described above, in detail, both for the initial and final years' data decompositions. Moreover, the similitude goes to the extreme that, in each sector, the effects exhibit the same signs and the ranking of the magnitudes doesn't change. The only difference with the CRS setting, comes from the fact that in some sectors the technical change effect has a different sign.

Overall, for the **VRS** framework we can conclude that, the variations in output are mainly explained by the catching up and the variation in inputs effects. When the output growth rate is positive, these effects are also positive, and when the growth rate is negative, the effects are negative too. The technical change effect doesn't exhibit always the same sign, being sometimes positive and others negative. These variation can be observed basically when move from initial to final year's data decomposition.

As mentioned before, apart from the decomposition of the output growth rate, in Chapter 2, we also calculate the *scale effects*. The objective is to identify the presence of increasing or decreasing returns to scale, and is motivated by the fact that the most important factor in explaining the variations in the output's growth rate was the inputs' usage. The intuition behind is that the presence of increasing returns to scale, i.e. would contribute to augment the explanatory power of the inputs effect in the variation observed in the output level.

In accordance with the theoretical definition introduced in Chapter 2, if the output growth rate is positive, and the scale effect is also positive, then there are increasing returns to scale. If on the contrary, the scale effect is negative then we have decreasing returns to scale instead. We breakdown the results for the positive and negative output growth rates cases, and several patterns can be identified based on the empirical findings:

1. *– Positive output growth rate*:
   (a) In sectors 172 (textile weaving), 175 (other textiles), and 252 (plastic products), we have found that positive output growth rate goes together with positive scale effects (increasing returns to scale). Moreover this is true, independent of the type of decomposition – initial or final year data. (b) In sectors 241 (basic chemicals) and 251 (rubber products) this is true only for the decomposition with final year's data. For the initial year framework, positive output growth rates are accompanied by negative scale effects or in other words, decreasing returns to scale. So, in these two sectors, when change from initial to final year's data, we move also from decreasing to increasing returns to scale.

(c) In sector 211, the positive output growth rate goes together with a negative scale effect, both with initial and final year's data. In other words, in this sector the technology exhibits decreasing returns to scale always.

2. - *Negative output growth rate*:

(a) In sectors 175 and 241, the scale effect it is always negative, both with initial and final year's data. This situation corresponds to increasing returns to scale. (b) In the rest of the sectors, 172, 211, 251 and 252, the scale effect is changing the sign from negative to positive, when move from initial to final year's data. In other words, according to our definition of scale effects, in these sectors, when change from initial to final year's data, we move also from increasing to decreasing returns to scale.

These scale effects confirm actually our previous conclusions based on the decomposition of the output growth rate, confirming the impact of the inputs' usage effect. Increasing returns to scale means that a proportional variation in the input factor will produce a more than proportional response in output (positive, if there is growth, and negative if the output is decreasing). For the case of decreasing returns to scale effect, the situation is the opposite: a proportional variation in inputs would produce a less than proportional variation in output. In other words, an output fall and decreasing returns to scale technology implies a substantial reduction in inputs.

In **Chapter 3** of the dissertation we analyse the firms' performance in costs, rather than in output. We work in a non-parametric framework, like in Chapter 2, with VRS, and *input* orientation this time given that we treat the dual problem of cost minimisation instead of output maximisation.

An important contribution of this chapter refers to the proposal of cost inefficiency estimation. The differences in cost among firms could be explained considering mainly two approaches: analysing the size of the firms or the level of the fixed inputs. In Chapter 3 we deal with the problem of fixed inputs and the capacity utilisation as determinant factor given that the literature sorted out the first approach long ago. Another value added of this chapter is given by the empirical results which allows us to contrast our conclusions with previous findings related in particular with the performance of the economies in transition.

The concept of capacity utilisation is treated here from the perspective offered by the economic theory of the firm, as a short-run concept hence, depending on the level of the fixed inputs of the firm. The methodology we apply is particularly stressing the distinction between short- and long-run. This refers to the fact that the fixed assets cannot be adjusted in the short-run, but only in the long-run, hence the impossibility of the firms to adjust them determines variations in the degree of capacity utilisation which are translated into cost inefficiency. In our case, the distinction between short- and long-run is given by the fact that in the long -run all inputs are variable (variable costs) while in the short-run we have bots fixed and variable costs.

We construct a best practice short- and long-run cost efficiency frontier, for each sector in the data set and measure several elements: capacity utilisation degree of the fixed assets in the short-run (CU), short- and long-run cost efficiency coefficients (SRE and LRE), and structural efficiency (SE) coefficients. We define one dimension for the output (turnover), and three dimensions for the inputs: material expenses, cost of employees, and depreciation.

In the long-run the fixed assets are adjusted with a depreciation rate calculated as explained in Chapter 3, for every year, at firm level. Then, inside each sector, we estimate for every country an average rate. The common feature of the depreciation rates reported is that in general in all countries and independent of the industry sector, they exhibit small values (below 40% and in some sectors like 211 and 241, even less than 30%). Moreover, in Bulgaria and Romania, the depreciation rates are in all sectors, particularly low (with few punctual exceptions, they oscillate between 5 and 10%).

One possible explanation of this situation could be that in these countries, in the post communist period have been introduced changes in the accounting systems. Fixed assets (firms' inventories in general) used to be evaluated based on their book value. The high inflation registered after the 90s' due to price liberalisation and the exchange rates applied, turned usually large amounts expressed in national currencies into rather small dollars amounts. Fortunately, we didn't have to handle here all these conversion and comparability problems, because the database already presents all data expressed in dollars. We only had to put them in constant prices (1995 = 100), adjusting for every country and sector with the corresponding Producer Price Indexes (PPIs). We thought also about adjusting for the differences in purchasing power parities (PPPs) among countries. Finally this possibility has been discarded because we wanted to avoid removing *ex ante* any calculations the natural differences existent among countries, and alter this way the final outcome. Turning back to the empirical results, we resume hereafter our main findings:

1. The *capacity utilisation degree* (CU), is calculated as a ratio of the optimal to the observed level of the fixed assets. We distinguish between: CU<1, which means under-utilisation (or excess of fixed assets); CU>1 is equivalent to over – utilisation (firms need to invest in fixed assets); and CU=1 which would be the case of the firms that have the adequate capital assets endowment, minimising costs in the long-run. We report average results for each sector, over the whole time period, 1995-1998, and disclose them by country.

   In sectors 172 (textile weaving), 175 (other textiles), 251 (rubber products), and 252 (plastic products), the firms with excess of fixed assets (CU<1) are the dominant feature (more than half of the total number of firms in each sector). The same conclusion holds at country level. The firms with CU ≥1 belong to France and Italy, and in some cases Belgium, Romania and Spain join also the group.

   There are two sectors, 211 (pulp, paper and paperboard), and 241 (basic chemicals) where dominates the over-utilisation of the existent capacity (CU ≥1).

In sector 211, this proportion goes from about 55% in 1995 to 65 – 70% in 1997 and 1998. In sector 241, the proportion is more stable and oscillates around 80% over the whole period.

Another aspect worthwhile to mention about the CU ≥1, is than in some cases we have to handle with very large values (above 15). For this reason we had to apply a Box plot test in order to identify possible extreme values. In fact we applied the test both for over– and under-utilisation cases. There are two sectors in particular, 241 and 252, where we identified extreme values and they are reported in the corresponding tables in the Appendix of the chapter. The number of the extreme observations may appear to be large but only at first sight. In order to ensure for the comparability of the results of a sector across years, we make sure the same extreme units are excluded from 1995 to 1998.

2. *The growth rate of fixed assets (GRFA)*, is calculated because we would like to get some more insights about the investment behaviour of the firms. The intuition is the following: when CU>1, firms are in need of capacity which means actually that there is incentive to invest in fixed assets. So we would expect the GRFA to be greater when CU>1 than when CU<1.

For this reason we calculate GRFAs and present the results separately for positive and negative GRFAs, and for CU<1 and CU ≥1. In five of the industry sectors, independent of the under- or over-utilisation being the dominant feature at sector level, the intuition was confirmed. In average, for CU ≥1, the positive GRFAs are greater than for CU<1. These sectors are: 172, 175, 211, 241, and 252. Only two punctual exceptions from the rule have to be mentioned: in sector 172, GRFA for 97/98, and in sector 241 the GRFA for 95/96. These means that when there is over-utilisation, firms also invest in capital assets. Moreover, if keep in mind that the units exhibiting CU>1 belong mainly to the market economies block, these countries are in fact the ones that mostly invest in fixed assets and hence in new technology. In some cases, Romania also joins the group but this pattern is not constant. The only sector were the intuition is not supported by the results is 251 (rubber products), and this is true for the whole time period.

These findings allow us to drive also some conclusions about the characteristics of the markets, and the business environment in general. In Chapter 3, in Table 4 (page 98) we summarise these conclusions in a double entry table. Most of the sectors (172, 175, 211, 241, and 252) belong to the profile defined by CU ≥1 and positive GRFA, or to the one characterised by CU<1 and negative GRFA (172, 175, 241). If focus on the first profile, this means that over-utilisation goes together with expanding markets environment and hence, growing investment in capital assets. The other profile, complements the excess of capacity with shrinking markets, and firms more likely to disinvest. In the case of sector 251, the fact that firms are not working at full capacity (CU<1) may be explained to some extend by the fact that they act not in a decreasing market but rather in a mature market environment.

3. We estimate also for every sector *cost efficiency* coefficients. We report results for short– and long-run (SRE, LRE) settings, and calculate also structural efficiency (SE) ratios. We report for each sector and year, average results. The cost efficiency coefficients are defined such that cannot take values greater than unity. The difference up to unit represent the potential costs savings that would project the firms to the efficient cost frontier.

In all sectors, we found that on average, firms are inefficient in costs both in short- and long-run (SRE<1 and LRE<1 in more than 90% of the firms analysed). The number of the cost efficient firms is small oscillating from 1% in some sectors up to 10% or a bit more in some others.

SE is calculated as the ratio of LRE to SRE. Given that in one hand, in most of the cases SRE and LRE coefficients fall below unity, and on the other hand, LRE is in average smaller that SRE, for almost all firms we found SE<1 as being the dominant feature in all sectors. With two exceptions, more than 95% of the firms, in each sector and for every year from 1995 to 1998 exhibit SE<1. So, firms are facing cost excess problems due to an inadequate fixed assets endowment in the short-run.

If look at the evolution of all indicators calculated, it can be noticed a soft tendency of cost inefficiency reduction (coefficients are getting closer to unit). Nevertheless, the improvement is far from being substantial and it could be very well due to the variation in the number of units from one year to another.

Overall, several general conclusions can be pointed out in Chapter 3: from the six industries analysed, in four of them we found on average excess of capacity (CU<1) and in the remaining two, over-utilisation of the existing capital assets (CU>1). We have to say also that, even if the under-utilisation is the dominant feature at sector level, inside the sector, the firms with CU>1 exhibit a positive GRFA greater than the GRFA corresponding to the units with CU<1. This implies that in average, the firms with over – utilisation do invest in capacity. Moreover, the firms with CU>1, belong in a greater proportion to the countries in the advanced market economies than to the countries in transition. In all sectors there is room to improve cost efficiency. All cost indicators, have values below unit: LRE<1, SRE<1, SE<1.

In **Chapter 4**, we take up the issue of analysing firms' performance in profits. We continue working in a non-parametric framework, with VRS, and this time with both output and / or input orientation. We construct a best practice profit efficiency frontier and the non-parametric technology is based on directional distance functions instead of the more common distance function concept.

In fact, Chapter 4 is a natural continuation of the analyses performed in the previous chapters. After maximising output in Chapter 2, we follow in Chapter 3 with cost minimisation, and finally in Chapter 4 we maximise the difference between revenue and costs.

The profits are calculated following the balance sheet approach as the difference between revenue and costs. The revenue represent our output dimension and in this case is given by turnover. For the cost (input) dimension we work with: material expenses, cost of employees, depreciation and interests paid.

Apart from the directional distance function technology, there are several aspects that mark the difference with respect to other related works on profit efficiency. We estimate best practice profit efficiency frontiers introducing additional constraints on: credits (total liabilities), fixed assets and interests paid. The objective is to quantify the impact on the firms' profit performance in order to see to what extent they are binding or not. Most of the existing literature deals mainly with expenditure/credit constraint or credit and investment constraints.

Moreover, the constraints are built for every unit in terms of other units' inputs. In this framework our constraints will affect the frontier technology: the fact that they are binding will be reflected by a shift inwards of the profit frontier. In other words, firms were not able i.e. to get more credits in order to reach the optimal profit frontier because of the binding credit constraints. This is actually a significant difference with other works on constraint profit maximisation where the constraints are constructed without affecting the frontier technology.

Another contribution comes from the fact that we link the credit constraints analysis to the literature on soft/hard budget constraints, first introduced by Kornai in the former socialist economies. A binding constraint is an evidence for firms facing hard budget constraints.

We first calculate estimates for our profit efficiency measure defined in Chapter 4, in the theoretical framework: we recall here, the Nerlove's profit efficiency measure (NPE) defined as the normalised difference between the optimal and the observed profits. NPE can be decomposed into technical efficiency (TE) and allocative efficiency (AE), (NPE =

TE + AE). We report results for NPE and NPE with constraints, for each sector and year, and for input and /or output orientation. The main findings are discussed hereafter:

1. *NPE coefficients*. Before making any comments, we recall that as the NPE measure represent the normalised deviation between optimal and observed profits, the greater the values of NPE, the less efficient (more inefficient) in profits is the firm analysed. According to this setting, for a firm performing on the profit efficiency frontier, the NPE measure should be zero.

   1.1. We look first at the NPE measure when *maximise profits without any additional constraint*. Our empirical findings put in evidence that on average, at sector level, firms are inefficient in profits (NPE>0). This inefficiency is present also, inside each sector at country level. If compare countries, we can see that the block of the advanced market economies is by far much more efficient than the two transition economies. The differences in the NPE measures among the two blocks vary from one sector to another, but in order to give an idea, they may go from values grater than unit, for the advanced market economies, up to values sometimes 20 and 30 times bigger, or more, in the case of transition economies. Another common feature to all sectors is that the NPE inefficiency is greater for the firms with losses.

   1.2. NPE measure with *constrained profit maximisation*. First of all it is important to stress the following aspect: when present the results, we group in a same table, the NPE measures both with constrained and unconstrained profit functions. The criterion applied is the direction of the normalisation: input and / or output orientation. This way we ensure the comparability of the NPE measures, given that the denominator (the direction of the normalisation) is always the same while the nominator (the deviation between optimal and observed profits) will reflect the influence, if any, of the constraints introduced.

Overall, for all constraints – credit (CC), interest paid (I), and fixed assets (FA) - we can say that on average firms continue to be inefficient in profits. The important aspect to focus on is that the constraints *are binding*. The way we see this from the data is that all NPE measures with constrained profit functions exhibit lower values than the measures without constraints on profits. This could be taken as firms being more efficient (lower values), but this happens not because they moved closer to the efficient frontier but on the contrary because the frontier shifted downwards, coming closer to the firms. In other words, what the values show is that now, with a credit constraint i.e., firms would need more credits in order to be able to reach the previous frontier.

If try to rank the results according to the direction of the normalisation we can see that the inefficiency is increasing when shift from input – output to output orientation, reaching the greatest values with the input orientation. This is true for all sectors and years. Another common feature to all sectors is that in average, profit inefficiency is increasing across time, being greater as we move from 1995 to 1998.

2. We were interested to see to what extent the introduction of the constraints produced statistically significant differences in profit efficiency among countries. When compare the NPE measures with and without constraints (NPE, NPE-CC, NPE-I, NPE-FA) across countries in a given sector, we could see that the inefficiency remains particularly high in the transition countries with respect to the others. If focus on the credit and interest constraints, the results could allow us to drive some preliminary conclusions about the financial markets in transition.

   For this purpose, we perform a paired samples *t-test* for each sector, and inside the sector for every country. We report estimates only for the input-output orientation. With the results obtained we can conclude that the differences among the NPE measures are statistically significant. Moreover, for a 95% confidence interval, the upper and lower bounds of the differences between the NPE measures are much greater for Bulgaria and Romania. For the market economies, on the contrary, the interval is very tight. This brings additional evidence to the previous conclusion about the constraints having a greater impact in the firms' profit efficiency for the transition economies.

Further on, putting these results into relation with the economic literature on soft / hard budget constraints, the fact that the constraints are binding confirm the hypothesis of firms facing hard budget constraints. The existent evidence confirms this hypothesis for public enterprises in countries like Italy, and is generally accepted for the countries in transition. In these countries in particular, the paternalistic attitude of the government, based on subventions and repetitive bail-outs of the loss making state-owned enterprises, has been replaced by a much more severe credit policy demanded by the financial markets. The financial problems together with the lack of demand continue to be seen by firms as limits to production throughout the period[30].

3. We also estimated a model for panel data, for each sector, and overall combining all sectors in the database. We were interested to look for possible explanatory variables of the profit efficiency measures: NPE, NPE -CC, NPE -I, and NPE-FA. At sector level, the explanatory variables considered were: countries, size,

[30] In Bulgaria, the % of manufacturing firms citing domestic/foreign demand as a limit to production, augmented from 33% in 1995 to 46% in 1998 and 52% in 1999. In Romania, the same indicator has increased from 19% in 1995 to 61% in 1998 and 72% in 1999. In Czech Republic i.e. the percentage varied from 20% in 1995 to 23% in 1998 and 28% in 1999. In Hungary it goes from 51% in 1995 to 69% in 1999, and in Poland from 50% in 1995 to 78% in 1999.

Concerning the supply side, the % of manufacturing firms citing financial problems (access to credit etc) as a limit to production shows the following pattern: in Bulgaria, it goes from 47% in 1995 and 56% in 1996 to 39% in 1998. In Romania, the same indicator increases from 43% in 1995 to 66% in 1998. In Czech Republic, the % is very low: 10% in 1995, 7% in 1996 and 1997, reaches a minimum of 2% in 1998, and increases steeply in 1999 up to 9%. In Hungary, it goes from 43% to 38% in 1998, and in Poland, from 57% to 30% for the same years.

The data are extracted from OECD, Centre for Co-operation with Non-members, "Transition at a Glance", 2001 Edition, page 14.

ownership forms, return on shareholders funds, and years. When combine all sectors, the variables are the same except that we replace years by sectors. The econometric estimates, turned to be significant (at 95% confidence interval) for several variables. We again report results only for the input-output direction of the normalisation.

3.1. *country*: we are interested to measure the heterogeneity in profit efficiency performance among countries. We introduce in the model seven categories (dummies) corresponding to the seven countries in the data set. When look at the NPE performance across countries, two in particular, Bulgaria and Romania, behave systematically different with respect to the reference country (in our case Belgium), and implicitly to the rest of the countries. They are significantly more inefficient in profits that the rest. This is true for the global panel and also at sector level. Only in few cases - sectors 172 and 175, -Spain, and Italy behave significantly different than the rest, but in their case, the inefficiency is much lower.

3.2. *size*: is expressed in absolute values, by the number of employees. The sign of the coefficient is negative and is it significant in all sectors, although not always for all NPE measures. Keeping in mind that NPE is a measure of inefficiency, the negative sign tells us that for every additional employee, the inefficiency will diminish with the amount indicated by the size coefficient. In other words, large firms are more efficient than the smaller ones, being closer to the efficient profit frontier.

3.3. *type of ownership (public, private and other)*: we introduce three categories for the three owner – types. The private ownership variable is significant in the global panel for the NPE measure, in the sense that private firms are less efficient that the public. As in our data set small firms are of private type, this result goes in the same line with the previous conclusion about large firms being more efficient in profits. At sector level, this control variable is not found to be significant, except some sectors like 175 (other textiles) and 252 (plastic products) although not for all NPE measures.

3.4. *return on shareholders funds*: this control variable was not found significant in the global panel but resulted to be statistically significant in almost all sectors, except for 211, in particular for the NPE-I measure (profit efficiency measure with interest paid constraint). The negative sign would indicate that the more returns on shareholders funds the more efficient is the firm. In fact more than an implication, the return on shareholders funds is a consequence of the firm being more or less efficient in profits.

3.5. *sector*: for this variable we considered six categories, corresponding to the six industries in the data set. The results put in evidence that sectors exhibit significant differences in profit efficiency with respect to the reference sector (172). They are more inefficient. This is especially true for the NPE and NPE-CC measures. For the NPE-I only two sectors, 211 and 252, behave significantly different, while for the NPE-FA measure there are the sectors 211 and 251.

3.6. *years*: time is a control variable introduced in the model for panel data at sector level. The pattern exhibit by this variable doesn't allow for a global conclusion common to all sectors. In general, except for sector 252 were for some profit efficiency measures (NPE-CC, NPE-I, NPE-FA) all years resulted statistically significant with respect to the reference year 1995, in the rest of the sectors, time is not significant. The only exception in some cases is marked by year 1998 which is significant in the sense of firms being more inefficient than in 1995.

Capacity utilisation (CU), already estimated in chapter 2, was also considered as an explanatory variable for the firms' profit performance. The sign of the variable, negative, goes in line with our expectations: i.e. the lower the degree of capacity utilisation (under-utilisation of capacity) the higher the firm's profit inefficiency. Nevertheless, the variable turned out to be not significant in almost all cases and for this reason, we finally do not report results on it.

Summarising, several conclusions have emerged from the analysis of the empirical results of Chapter 4. We have found that on average, firms are facing profit inefficiency problems and this inefficiency is much greater in the countries in transition. We have also found that profit inefficiency is on average, increasing across time. If take into account the direction of the normalisation, input and/or output orientations settings, in explaining profit inefficiency, then input-output goes first followed by output and in the third place comes the input orientation, with the greatest NPE coefficients.

The empirical findings have confirmed that the additional constraints introduced are limiting the profit efficiency performance of the firms. In particular, they resulted to be especially binding in the transition countries. The econometric estimates of the panel data model, both global and per sector, put in evidence that the two transition economies are significantly more inefficient in profits that the developed market economies. Size and ownership type are also significant, supporting the idea that public firms are more efficient in profits than the private ones. The returns on shareholders funds doesn't play an important role in explaining firms' performance, except very few cases. The differences in profit performance vary also across sectors, and in some sectors, across time too.

The General Conclusions here presented, are the result of both the theoretical background and the data set in which this dissertation is founded. Nevertheless, there is room to build on the results already obtained here, eventually improve some of them, as well as to take up new research topics not treated here.

The limitations related to data availability have already been mentioned in the Introduction. Would have been without doubt more desirable to have had in the data set more countries in transition like i.e. Czech Republic, Hungary, Poland or the Baltic countries, as well as other missing countries in the EU block like Germany or maybe United Kingdom. If were to speak about some of the variables included in this data set, we worked with the number of employees, but for comparability reasons would have been maybe more appropriate to work with the hours of work. Fortunately, the methodology we applied in this dissertation, allowed us to handle this limitation and present reliable results.

Concerning the empirical results, the objective pursued was that each chapter would try to present a different dimension such that to permit us to study the same data from various perspective. For this reason, in Chapter 2, i.e., we do not insist very much in grouping the results per countries, but rather work at sector level. Next, in Chapter 3, we present CU result per country as well, and finally in Chapter 4 we insist even more in disclosing the empirical findings per country, separating profitable from loss-making firms.

Another aspect to mention, is related to the type of analysis performed. In spite of the fact that we do give a temporal perspective of the results, the analysis per se is *static*, analysing each year separately. Next step to follow would be to change to a *dynamic* setting which could allow us to quantify the changes observed from one year to another.

As already mentioned in the Introduction we move gradually from a less to a more restrictive methodological framework. Nevertheless, the link between chapters could be reinforced even more by correcting *a priori* the data for the eventual presence of technical change. We are also interested to incorporate in the research aspects related to the corporate governance issue like i.e. the structure of ownership of firms: the blocks of shareholders inside firms, what percentage of shares they control, domestic vs. foreign shareholders, the distribution of the voting blocks, and the relationship between the ownership structure and the performance of the firms viewed with a non-parametric methodology. Another extension of the present research could be given by the study of the relationship between trade patterns and performance in efficiency among countries or within groups of countries. These are only some ideas for future investigation although the list could be enlarged.

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