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Industrialisation and the Role of Competitive Advantages: A Micro Level Analysis of the Determinants of Chilean Plant Efficiency

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Abstract:

Industrial competitiveness of a country relies on the competitiveness of its firms and their specialisation. We argue that both trade and industrial policies are important to increase it, but while the first alone push toward the reliance on the only static comparative advantages, the latter crate dynamic assets. We test how they both affect the efficiency of Chilean plants, a country strongly specialised in resource-based commodities, using 'one-step' stochastic frontier production estimates. We find that local endowments have mainly an indirect effect, through plant's characteristic. Nevertheless, we confirm that the supply of dynamic assets has an essential role, and external sources of knowledge are also important. However, we warn that the latter, if not supported by local complementary efforts, can have negative effects on the long-run growth.

Keywords: Plant efficiency; Stochastic Production frontiers; Manufacturing sector; Industrialisation; Choice of Technology;

JEL classification: D24; L6; L52; O14

♣The present work is the result of an analysis conducted while the author was following a postgraduate course at the Graduate School of Social Sciences at University of Sussex, and benefited from the supervision of Prof. N. von Tunzelmann (SPRU).

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0. PREFACE

In the following paper we face the debate on the relation among openness and industrialisation in developing countries.
The analysis is focused on the different role that static and dynamic comparative advantages can have in enhancing a developing country industrial competitiveness. In fact, we stress the limits of the first, which can hinder long-run development, locking a developing country in a low growth path. Conversely, we acknowledge the importance of the latter, contemporaneously stressing the difficulties behind their creation, which require the implementation of industrial policies.
The approach used differs from the previous studies on the subject, which have dealt with aggregated data or have analysed the direct impact of export on plants. In particular, we analyse both the role of openness (together with the concentration on static comparative advantages of manufacturing activities) and of industrial policies (aimed at the creation of dynamic assets) on plant efficiency. We concentrate on Chile, a country that have built its industrialisation on natural resources, using the ENIA plant survey, which accounts for all enterprises with more than 10 employees. Data on local endowments is drawn partly from the household survey CASEN, partly from national institutions. The first are at the municipal level, while the second are disaggregated per region.
A cross-plant analysis is carried, as we have information at the municipal level only for the years 1996 and 1997, dividing the sample by 9 sectors of manufacturing activities. We estimate the efficiency using a one step stochastic frontier approach, and a translog production function. The first allow for different distributions of the (in)efficiency term for each plant, while the second can approximate almost any functional form.

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1. INTRODUCTION

"Does trade promote innovation in a small open economy?" "It depends"[1].

Debates on openness and trade, and their impact on the growth and industrial competitiveness of nations, have been one of the major topics of discussion in economic development[2]. Part of the empirical analysis that underlies the discussion is conducted at the level of how trade (or distorting restrictions) can directly affect growth[3]. Another smaller group of work sets out the impact of trade on a set of variables that are assumed to be linked with growth or competitiveness[4]. In both cases it is difficult to separate the effects of trade from all the other determinants that directly or indirectly affect the evolution of the industrial sector[5], without mentioning the problems of computing an indicator of trade openness. A third problem is that, in most cases, there is no clear knowledge on how the elements affected by trade impact on competitiveness in their turn. Finally, an extensive literature has been built on descriptive analysis of the changes in the productive systems of countries in the decades following trade liberalisation[6].

Conversely, most of the theoretical analysis has been based on very restrictive assumptions that hardly represent real-world dynamics[7]. Only more recently have theoretical contributions taken into account the relevance of market failures and, in a very few cases, of selective polices.

In the present work we focus our attention on the role of comparative static advantages and competitive dynamic advantages, which can be seen respectively as outcomes of free trade and selective industrial policies. The former are mainly natural endowments, and do not require any kind of intervention, while the latter are assets created through policy interventions. We build our argument on the theoretical and empirical evidence that an industrial strategy based only on natural resources (say primary resources and abundant unskilled labour) does not generate a long-run growth path (for a brief review and references, see Rodriguez and Rodrik 2001). In fact, the different technological endowments are the main determinants that drive the countries through dissimilar (possibly diverging) levels of competitiveness (Dosi *et al.* 1990).

Likewise, just as countries differ in their level of technological development, firms within a country specialise in products and processes that have different technological intensities. And their different patterns of specialisation, together with the institutional shape, are the main determinant of national competitiveness. We claim that country competitiveness depends on the technological intensity of the products in which firms specialise and of the processes they use. At least this is the idea behind the industrial strategies of developed countries, as stated by the American National Science Board: "*High technology industries* are important to national economies because they *produce a large share of innovations*, including new products, processes and services that help *gain market share*, *create entirely new markets*, or *lead to more productive use of resources*. High technology industries are also associated with *high value-added production*, *success in foreign markets*, and *high compensation levels*. Results of their activities *diffuse to other economic sectors, leading to increased productivity* and business expansion" (National Science Board 2002, p o-8) (italics ours). Nevertheless, upgrading in both products and processes is achieved through lengthy learning dynamics that have to be backed by institutions, through the provision of competitive assets.

We concentrate our analysis on Chile, a country that has followed a pattern of industrialisation strongly based on natural endowments, and is recently experiencing a halt after two decades of strong growth. In particular, we aim at understanding what are the determinants of plant efficiency in the manufacturing sector,

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[1] Slight paraphrase of Rodriguez and Rodrik (2001, p.6).

[2] For a brief review and references on the same topic see for example Winter (Winter 2000).

[3] The literature is really extensive. For two recent works reviewing some previous results and methodologies see Rodriguez and Rodrik (2001); Subramanian and Roy (2001).

[4] See for example works on structural reforms (White and Levine 2000).

[5] Most of the studies control for different determinants, but there is no control for possible correlation among them and openness.

[6] For the Latin American case see for example references in section 2.2.

[7] As Romer observes, "According to this approach, if we want to discourage counterproductive restrictions on trade and foreign investment in most countries of the world, then the right model is one with perfect markets so that intervention can be shown to be everywhere and always a mistake." (Romer 1993, p66).

in order to shed some light on the role of static and dynamic advantages. We analyse them across plants in different sectors, and different localities in the country. The first categorisation is useful to divide plants according to the technological intensity of products and their reliance on local resources. The latter provides some information on the endowments, both natural and created, that factories can exploit locally.

We use a flexible form of the production function that allows us to avoid any hypothesis on elasticities and returns to scale. Besides, we adopt a particular form of the stochastic frontier approach, which permits estimating in one single step the frontier production function, the inefficiency measure of each plant, and the determinants of the efficiency. This method does not require the assumption of an identical distribution of inefficiencies across plants, allowing for the more realistic acknowledgement of idiosyncratic factory/plant characteristics.

Thus, the paper is structured as follows. In the next section we delineate the theoretical and the national framework, the spaces in which our analysis is built. We then conclude the section with a brief discussion of the advantages of adopting a micro-level approach. In section 3 we explain the methodology of the analysis; we first provide a brief survey on the stochastic frontier approach, and then explain the advantages of using a one-step procedure for the estimation of the determinants of efficiency. The form adopted for the production function is defined. In section 4 we proceed with the description of the manufacturing categories (and the rationale behind it), and depict data sources and variable construction and selection. The final model is then presented. Section 5 contains the econometric analysis, its main steps, and an evaluation of the results obtained. We then conclude with some final considerations in section 6.

2. COMPARATIVE ADVANTAGES AND TECHNOLOGICAL CAPABILITIES IN THE INDUSTRIALISATION PROCESS: THEORETICAL AND EMPIRICAL FRAMEWORK

In the present section we delineate the theoretical framework adopted which has led to the subsequent empirical analysis. Then a brief description of the available evidence on the Chilean industrial achievements is provided. In the last section we explain why we have adopted a micro level analysis and how it can contribute to the debate presented in this section.

2.1. The theoretical framework

As a premise, we underline that we introduce here a theoretical *framework*, which is meant to delineate the theoretical space of the analysis. We suggest there is a certain difference between such a framework and a theoretical model, in which a precise set of causes and effects is posited[8].

It has been broadly acknowledged that trade has a positive effect on countries' growth, both developed and developing (e.g. Dornbusch 1992; Krueger 1997; Rodrik 1999). To avoid leaving space for any doubt, Anne Krueger states: "while other policy changes *also* are necessary, changing trade policy is among the *essential* ingredients if there is to be hope for improved economic performance" (Krueger 1997, p.1) (italics ours).

Although the empirical evidence on the direction of causality between trade and growth is not as clear as Krueger poses it (Fung *et al.* 1994; Rodrik 1999), and although it is not a simple task to measure a country's openness (Rodriguez and Rodrik 2001) and thus conclude about its role in growth, we agree that, broadly speaking, a closed system has less opportunity to 'develop' as it does not have knowledge inflows and is constrained by lock-in effects (Arthur 1988).

Nonetheless, we enter the debate at a lower level, assessing the *essentiality* of "other policies" aimed at the creation of 'dynamic' comparative advantages (Dosi et al. 1990), given the trade regime. In fact, while Krueger's views about the key role of openness is based on the Heckscher-Ohlin (H-O) model (Krueger 1978), we borrow our framework from 'neo-keynesian' and 'neo-schumpeterian' trade theories[9]. Ultimately,

[8] If an analogy is allowed, they can be respectively compared to a square in which various shapes can be drawn and a one-directional line, the shape of which has to be defined.
[9] As will be clear in the following schematic descriptions, many complementarities apply among the two approaches.

we reject the hypothesis that developing countries should base their industrialisation strategy exclusively on 'static' (allocative) comparative advantages, and acknowledge the importance of selective industrial policies in order to sustain dynamic advantages[10].

From the neo-schumpeterian perspective, the technological factor plays a central role in the definition of trade patterns (Cimoli and Dosi 1995; Dosi et al. 1990). In the first instance technology is not assumed to be readily available and transferable from one country to another (not even from one firm to another), which means that the conditions to 'understand' technological knowledge have to be created. In particular, there must be a process of learning, which is not an automatic outcome of trade but needs effort, time and knowledge building (Katz 1985). While these processes are mainly performed by firms, there is quite extensive evidence that it has to be backed by institutions, not only in correcting distortions, but also in the creation of assets[11].

Borrowing the concept proposed by Cohen and Levinthal (1990), and adapting it to development issues, the role of absorptive capacities is crucial, at the level of both productive and institutional bodies[12] (micro and meso level). To progress in the process of development, countries need not only to 'understand' and use new technologies, but also to learn how to create new ones, generating an endogenous capability to innovate. From those perspectives Bell and Pavitt (1993) distinguish between technological capabilities and production capacities[13]. This "'capability approach' suggests that comparative advantage depends more on the national ability to master and use technologies than on factor endowments in the usual sense" (Lall 2000, p.4). Thus, the path that has driven the country to the present level of development has a crucial role in determining future possibilities of growth (Dosi et al. 1990). A key element is the cumulative characteristics of knowledge, as a strong knowledge base increases the capability of acquiring and producing new knowledge in the future.

From this perspective it appears that the H-O approach is a useful tool only in conditions of perfect competition and equal distribution of technological capabilities. But in a world where those conditions do not apply, and market failures are more the rule than the exception, there is space for multiple equilibria, where developing countries specialise in low technology goods, with low value added (Redding 1999). The negative effects of specialising in static comparative advantages were formalised by Krugman (1987) in a model in which output depends on labour and increasing returns to learning, and productivity depends on an index of cumulative experience which is related to labour intensity and sector of specialisation[14]. The author shows that when those determinants are taken into consideration there is space for infant industry policy, in order to increase the cumulative experience. Similarly, he analyses the case in which specialisation in production based on natural resources leads to lower competitiveness[15] in the long run.

The demand side also plays a crucial role, so far as both domestic and international terms of trade are concerned. From a Kaldorian-Keynesian perspective, the idea is readily shown in a two-good closed economy. If the terms of trade of one of the goods are very low, the production of the other sector will not have much space for increase, as the overall country demand is low (Thirlwall 1992). Shifting to the international perspective, Kaldor assessed the importance of export-led growth as a means to increase national manufacturing production, but he also argued that the international terms of trade negatively affect the developing countries (Fagerberg et al. 1994). Such evidence had been observed and theorised about twenty years before by both Prebisch and Singer, and their analyses had led to the adoption of the Import Substitution policies (Prebisch 1950; Singer 1950).

[10] We also recognise the presence of government failures, but these go beyond the purposes of the present study.
[11] For e brief review of the most important types of policies used by developed countries see Fagerberg *et al.* (1994).
[12] Absorptive capacities are defined as the abilities to recognise new knowledge (in the wider sense of the term), discern it and apply it to productive ends.
[13] The difference is better explained by the authors: "We draw a distinction between two stocks of resources: production capacity and technological capabilities. The former incorporates the resources used to produce industrial goods… Technological capabilities consist of the resources needed to generate and manage technical change" (Bell and Pavitt 1993).
[14] We direct the reader to the original article for the model's construction and the complete list of hypotheses.
[15] Krugman would have never used the term 'competitiveness'; though it seems quite appropriate, as the model results indicate that wages and market share of the country 'reduce permanently'.

The main point here is that developing countries export in sectors that have low price elasticities and value-added, and base their production on minimum wage rates (which keep down internal demand). Hence, exports may grow, but if their value is very low and imports grow faster, the growth rate would be hindered by the negative balance of trade. Thirlwall (1979) presented a growth model that depended on the balance of payments equilibrium and the income elasticity of demand for imports. He showed that country growth rates are strongly and positively related to export increase (which depends on the export elasticity of the goods internally produced) and negatively to the import elasticity (Thirlwall 1979). The author concluded that growth ultimately depends on the characteristics of the good internally produced, as these affect their export dynamics and the propensity to import substitutes.

The above framework has been formalised in a model of a continuum of goods, where it is shown that the rates of growth across trading partner countries (i.e. the global world economy) differ on the basis of both the balance of payments and technological constraints (e.g. Cimoli 1994; Cimoli and Soete 1992). The two restrictions depend on the technological specialisation and capabilities of the countries, as the first is affected by the relative elasticities of the domestic and foreign goods, the latter by the technological gaps among them (measured in terms of productivity and technological intensity of goods – process and product innovations).

Given the scope of our analysis, we present here a simplified version of the model drawn from Cimoli and Correa (2002), in order to sketch the main elements of the framework . The model is based on two countries (domestic and foreign), a continuum of n goods, and only one factor of production (labour). Define by M the total demand for imports in the domestic country; Y^* the domestic income; E^{Ψ} the demand for exports of the domestic country (equal to imports of the foreign one); Y the foreign income; Ψ the technological multiplier (that proxies for the technological constraint)[16]; and p and p* the foreign and domestic prices respectively. The equilibrium of the balance of payments (used to close the model), in one single currency, is defined by:

$$M(Y^*, p) = E^{\Psi}(Y, p^*) \qquad (1)$$

The rate of growth is defined in equations (2), (3), and (4).

$$\dot{y} = \frac{\Psi}{r}\dot{E} \qquad (2)$$

$$\Psi = \frac{\dot{p}^*}{\dot{p}} \qquad (3)$$

$$r = \frac{\dot{M}}{\dot{y}} \qquad (4)$$

where $\dot{y}$ is the GDP growth rate; ρ the income elasticity of imports[17]; $\dot{M}$ the import growth rate; $\dot{E}$ the export growth rate; $\dot{p}^*$ the productivity growth rate in the home country (Chile); $\dot{p}$ the productivity growth rate of the foreign country (international best practice).

Equation (2) shows that an export expansion strategy per se is not a sufficient condition to guarantee a sustainable rate of growth. In fact, the effect is counterbalanced by the elasticity of imports[18] (4) and the

[16] In the original model Ψ is a function of the change in wages (both prices of the productive factors and determinants of income) and of the number of goods produced by the home country (on the continuum of goods ordered by ‘technological intensity’). This second outcome defines a ‘border good’, which is modelled as a function of the productivity and wage ratio between the foreign and home country. In the version of the model presented here the specialisation pattern effect is included in the elasticities.

[17] Which is conceptually very similar to the Harrod-Kaldor trade multiplier.

[18] In the extended model elasticity of exports are modelled as the import elasticity of the foreign country and differs (as here) according to the technological factor Ψ. Likewise, the income growth of the foreign country is accounted as a determinant of export. For sake of simplicity in the version presented here, foreign income and elasticity are implicit in the export rate of growth.

industrial structure of the economy (3). While the first proxies the specialisation pattern of the country and the importance of the demand side, the latter shows the role of technological competitiveness in terms of productive efficiency. In a sense they can be respectively interpreted as product and process technologies. The model, in Keynesian fashion, does not contain an exchange rate variable, which is in fact assumed to change as a function of micro patterns. The author argues that empirical evidence suggests that Latin American countries have modified their exchange rates, following balance of trade constraints. We acknowledge there is an interaction among the micro and macro variables, but we are here using the model to explain the framework in a stylised form and we will not enter this aspect of the debate[19].

In summary, while the growth of exports is an important issue, and might even be essential (thinking about small countries like Chile), we assert that it is effective only when other essential complementary policies are implemented. In particular, conditions have to be set in order to increase the trade multiplier (Ψ/ρ). The model points out that it is necessary to specialise in sectors with high elasticities in order to reduce the balance of payments constraint (lower ε)[20], and to increase the efficiency of the production in order to decrease the technological gap (higher ψ). Thus, accumulation of knowledge and technology enters the model in two ways. On one side it increases the specialisation in high-tech productions, as technology-intensive goods experience higher growth patterns in trade, and "tend to be highly income elastic" (Lall 2000). On the other side, it increases the 'productivity' of the industrial sector and of the entire economy.

The role of imports is important as a driver of new knowledge. Nonetheless, imports should be used as a means for creating new knowledge and not to substitute for it. The same concept applies to the third outcome of openness, FDI. To have a positive impact on the country's industrialisation, foreign direct invetsments should be carriers of knowledge and not only exploiters of local endowments[21].

Thus, we partly disagree with Krueger when she argues that "labour-abundant developing countries probably would be well-advised to specialise in the export of labour-intensive products" (Krueger 1978, p274). We agree with Romer when he states that the import and 'use of ideas' is important in the short period, but in the long run countries need to learn to 'produce ideas' (Romer 1993). We would actually go rather further, recalling that the import and use of ideas is possible only if there are the local conditions for their understanding.

In this framework skills play a crucial role, as more educated people will be more able to change and adapt, speeding up the process of absorption and diffusion inside the country (Nelson and Phelps 1966). Nevertheless, in an industrial upgrading process, general knowledge is a necessary but not sufficient determinant, as it has to be applied to specific technologies (Lall 2001). It is not unlikely for the supply of skilled labour to be higher than the demand; in fact, routinisation of processes leads to a reduction in the demand for skills and only the implementation of innovative processes would require more skills (Wolff 1996). The process of substitution of capital goods production by imported equipment might lead on to a national deskilling path, reducing the demand for skills and rendering educational policies less useful.

Ultimately, it is not a question of 'simply' resolving market failures, which could correct the distortions from an ideal static equilibrium. Policies are particularly needed to move developing countries on to dynamic disequilibrium growth paths, with a shift of focus from static to dynamic comparative advantages (Lall 2001). The former have to be used to gain 'resources' that allow this shift.

2.2. The country framework

In the light of the theoretical framework we briefly present some of the main empirical evidence on the industrial and innovative structure of the country of analysis. Different studies of Latin American industrial

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[19] As mentioned in the introduction, we drive our analysis in one single country, thus controlling for macro determinants across plants.

[20] It is unlikely that small developing countries can influence the world economy, increasing their import rates.

[21] We do not have the space here to enter more in depth in the FDI debate, as what it matters in this section is a framework in which also the role for FDI should be analysed. For a discussion on their role in development and the different typologies refer to Blomström and Kokko (1997); Markusen and Maskus (1999).

dynamics after the structural reforms have underlined how most of the countries have concentrated their production only around their static comparative advantages, based on abundant endowments (as well predicted by the H-O model). On one side the countries in the southern and Andean regions (cono sur), which are focusing mainly on primary resources and non-tradable goods (e.g. Alcorta and Peres 1998; Benavente 2002; Benavente *et al.* 1998; Cimoli and Katz 2001; Katz 2001; Katz and Stumpo 2001). On the other side, the Central American countries (led by Mexico) have a great part of the industrial production concentrating in the maquila sector (assembling industry) characterised by low wages and low skills (e.g. Capdevielle 2000; Capdevielle *et al.* 1997; Cimoli 2000; Dutrénit and Capdevielle 1993; Dutrénit and Vera-Cruz 2002). Following this pattern it is quite clear that local effort in the production of more dynamic goods is crowded out by the increasing imports of capital goods (Katz and Stumpo 2001).

Focusing on the Chilean case, we first mention a recent study that analyses the intra-regional trade using a taxonomy that classifies goods according to their world trade dynamism (high, medium, low or stagnant)[22] (Benavente 2002). The figures indicate that during the 1990s, high dynamic products have not increased their shares, medium and low dynamic ones have increased very little (more the low dynamic), and the stagnant goods have increased a lot. The results in international trade show an even more pessimistic pattern, with a strongly negative performance of the first category and a highly positive one of the fourth category (measured as country shares in the world market). This appears to repeat the Prebisch-Singer result of many years ago, discussed above.

Since the trade reforms, which in Chile were implemented in 1973, the rates of growth have been on average quite high up to 1997, when the country entered a recession that is still going on (ECLAC 1999). The export participation in the world market has increased more than the Latin American average but not impressively, growing from 0.23% in 1985 to 0.32% in 1998. But the country has had one of the most evident shifts toward commodity production in the region from 1970 to 1999. Sectors with high engineering content reduced their share in national manufacturing from 25% to 15%; labour-intensive traditional sectors decreased from 31% to 25%; while resource-based commodities grow from 45% to 61%. The reverse occurs on the import side, with an impressive increase in capital goods and the consequent reduction in the trade balance over the 30 years (Katz and Stumpo 2001).

Those patterns clearly show that the Chilean industrial sector is basing its development on the comparative advantage of natural resources, provided by its coastal length, large amounts of forests and mineral resources[23]. They appear to be exactly the kind assumed by Krugman (1987) in his model where he demonstrates that they yield a reduction in national market share and wages. Another recent analysis of Chilean industrial development simultaneously assesses the country's trade specialisation patterns, the terms of trade deterioration, and the industrial structure and sectoral linkages (Cimoli and DiMaio 2002).

Concerning the first point, through a Competitive Analysis of Nations (CAN), it is shown that the Chilean foreign market share gains in dynamic sectors[24] have fallen from 66.3% to 18.8% from the 1980s to the 1990s. This shift is due to the concentration in primary commodities and non-tradable goods, and confirms a dynamic of production specialisation in sectors that have low income and price elasticities. The test of the Prebisch-Singer hypothesis on the evolution of the terms of trade shows that they have reduced almost monotonically since the 1970s. Finally, an input-output analysis is carried out in order to evaluate the process of substitution of local inputs by imported ones. Evidence of a de-linkage dynamic is found, for manufactures related to both the local and the foreign market. The replacement of local producers of capital goods not only is a cause of the decrease of the terms of trade and a reduction in the export of dynamic

[22] The study is based on the idea that goods with higher technological content (OECD classification in Hatzichronoglou 1997) are also those that are more dynamic in international export growth (Lall 2000; Mani 2000). Dynamic goods are those that increase their export more than the average growth, computed using the CAN software (ECLAC and World-Bank 2000).

[23] Chile produces almost one third of the world's copper, and has large amounts of other minerals (metallic and non-metallic) (INE 1998) and has an estimated area of protected forest that represents 18% of the country (world average is 5%) (Source: INFOR web site (http://www.infor.cl/).

[24] Sectors that have increased their export share more than average both in the analysed country <u>and</u> in OECD countries (ECLAC and World-Bank 2000).

products (Krugman 1987), but can also have longer term consequences, in reducing capital and skill formation through the reduction of skill demand.

2.3. A micro level analysis

An effort has to be made to understand the dynamics at a more micro level, in order to assess whether firm competitiveness increases through the provision of competitive advantages. The importance of addressing the analysis at the plant level draws on the idea that they are the main 'repository of knowledge' of production and the main driver of technological innovation (Nelson and Winter 1982).

The received empirical literature has mainly analysed the relations between trade and firm productivity. The evidence is quite mixed, and actually mainly depends on the techniques adopted. While it is generally acknowledged that exporters are more productive than average, it is only recently that authors have taken into account the presence of self-selection bias. In fact, it has to be analysed whether exports directly increase productivity or, conversely, the most productive firms succeed in the export market. Clerides *et al.* (1998) find that exporters from Colombia, Mexico and Morocco are more productive than average, but that self-selection plays an important role. Aw *et al.* (2000) find no evidence of learning by exporting in firms in Korea and that self selection is the main determinant of firms entering and exiting the market in Taiwan. Finally, Bigsten *et al.* (2000), using a two-step stochastic frontier approach, report both self-selection and positive learning effects in firms from four African countries.

In the present work we avoid discussion of the direct role of exports, and we concentrate on the determinants that in first instance affect plant efficiency. We have already stated that a developing country gains from exporting, but we have shown in the theoretical framework that it can be a spurious effect. If there is no effort of 'upgrading' the industrial specialisation and the efficiency of manufacturing, export increases can have no impact on growth. Hence, we are going to analyse to what extent the productivity of the plants depends on dynamic assets and natural endowments, and on how they are both located across the country. Further, we check whether their impact differs across sectors, in particular discriminating among resource-based and technologically intensive ones.

The issue is of central importance because the extent to which enterprises learn from exporting depends firstly on whether they access the foreign market, which is the case if they achieve a certain degree of efficiency. Secondly it depends on their ability to capture external knowledge, which in turn depends on their cumulated capabilities (Cohen and Levinthal 1990). Besides, the fact that exporting plants are more productive than average does not guarantee that the country as a whole is developing a competitive industrial system, as this in turn depends on how those advantages spill over. Actually, the present development of the Latin American region shows a high degree of polarisation, which has also increased the economic concentration toward a monopolistic structure (Benavente et al. 1998; Katz and Stumpo 2001).

To conclude, we aim at understanding whether selective industrial policies are essential, ancillary or useless in Chile, using an inductive approach. The former would be true if they increase the efficiency of the plants (enhancing their competitiveness), and if they increase the incentives to shift production toward more dynamic sectors (increasing national competitiveness). Whether, on the contrary, plants gain more from the exploitation of static comparative advantages, the latter condition would apply and openness would be the only essential policy. We leave open to discussion whether the results can be generalised.

3. THE STOCHASTIC FRONTIER MODEL AND FIRM (IN)EFFICIENCY

In the present chapter we describe the econometric technique adopted to estimate the efficiency of the plants. First we briefly overview the idea behind the stochastic frontier models, then we present the particular form adopted in the present study, and finally we describe the form of the production function we estimate.

3.1. Stochastic frontier models

Stochastic frontier estimation is here used to compute the 'optimal' production frontier and the (in)efficiency in the production process of each plant, along with its determinants. The methodology has its origin in the techniques proposed by Farrell (1957) for the measurement of technical and allocative efficiency[25]. Those measures are computable only if the production function is known, which is never the case in reality. Hence, Farrell's idea was to estimate it, using either a non-parametric approach such as the data envelopment analysis (DEA), or assuming a functional form. Stochastic frontier methods originate from the latter.

We begin by considering output (y) as a function of the inputs (x), such as Y = f(x). This relationship is practically never fulfilled, in the sense that, given a certain amount of inputs, the observed output will usually be less than f(x), due to the inefficiencies of the enterprise.

In order to compute these distances the frontier methodology was first adopted in a deterministic way (Aigner and Chu 1968), using data on the outputs and inputs of different firms and assuming a functional form in order to estimate its 'optimum'. In this approach, the error term is considered as the measure of inefficiency and is assumed to be non-negative. Recalling previous simple formalisation, and considering input variables in logged form, the model would appear as follows:

$$\ln(Y_i) = \beta_0 + \sum_i x_i \beta_i - u_i, \quad u_i \geq 0 \tag{5}$$

where now the x_i represent a k vector of inputs (expressed in logs of quantity or values), β_0 is the constant term, β_i the vector of parameters that are estimated, and u_i the random error term which has to be non-negatively distributed and which proxies the inefficiency of firm i.

If we call EFF_i the efficiency of the ith firm, it can be derived from the estimation results through the following expression:

$$EFF_i = \frac{Y_i}{e^{x_i \beta + \beta_0}} = \frac{e^{x_i \beta + \beta_0 - u_i}}{e^{x_i \beta + \beta_0}} = e^{-u_i} \tag{6}$$

According to the expression above, the efficiency is maximised when the inefficiency is equal to zero (u_i=0), and it ranges between 0 (when $u_i \to \infty$) and 1.

The deterministic approach suffers from a severe theoretical and practical shortcoming as the residual might include stochastic deviations from the frontier and measurement errors, as well as deviations due to inefficiency (Greene 2000).

This problem has been corrected with the adoption of the stochastic approach, which takes into account that firms might be distant from the ideal production function partly due to effects which are not accounted in the efficiency deterministic term (Aigner *et al.* 1977). Equation (1) would then assume the following form:

$$\ln(Y_i) = \beta_0 + \sum_i x_i \beta_i + \varepsilon_i \tag{7}$$

where

$$\varepsilon_i = v_i - u_i, \tag{8}$$

$u_i \geq 0$,

$v_i \sim N[0, \sigma_v^2]$; i.i.d.

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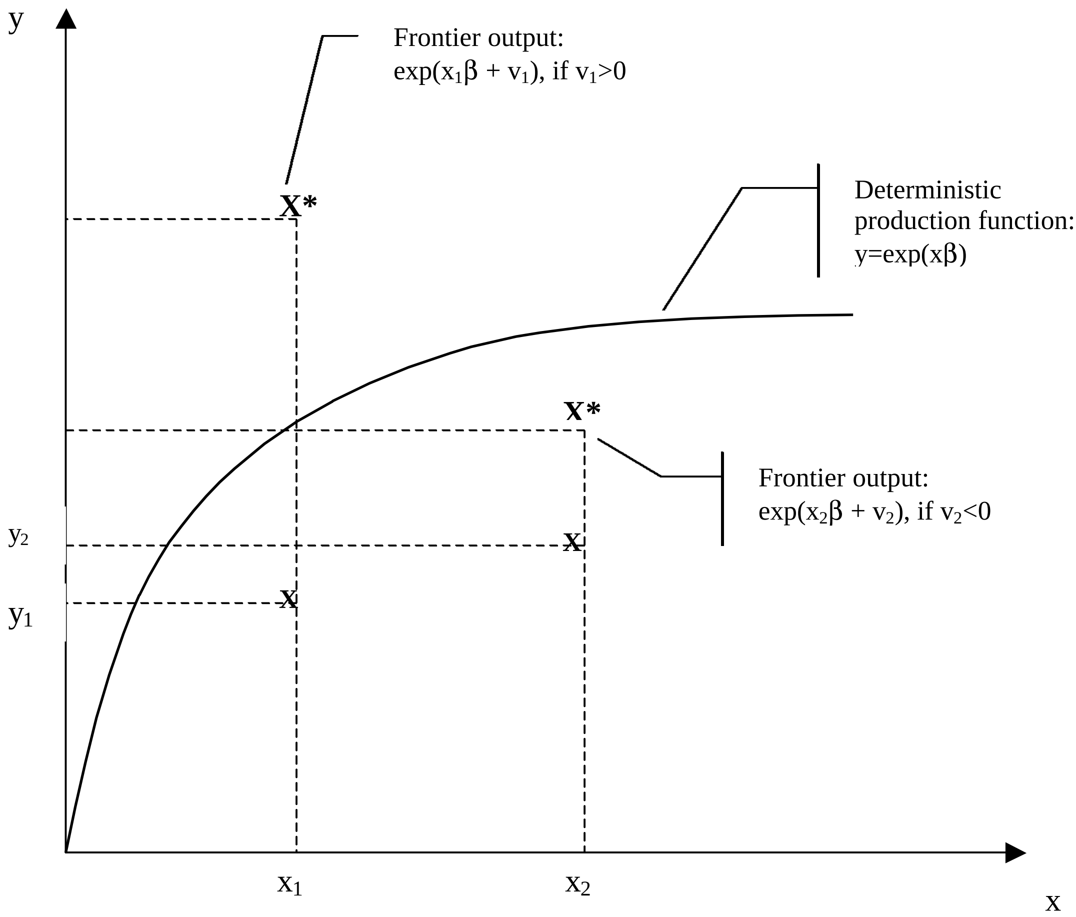
[25] Technical efficiency is defined as the ability to produce the maximum feasible output given a set of inputs, while allocative efficiency is defined as the ability to produce a certain output with the optimal share of inputs, which minimise their overall cost (see for example Gravelle and Rees 1992).

In this formulation, while the u-term is still positively distributed, the v-term is a symmetric disturbance, assumed independently and identically distributed (iid). Hence we now allow the production function to move independently from the plant's efficiencies, which means that the output results are now bounded by the random variable $\exp(x_i\beta + v_i)$ instead of the deterministic $\exp(x_i\beta)$ (Coelli *et al.* 1998). We illustrate the main concept of the stochastic frontier production function for the single input case in Figure 3.1.

Figure 3.1 – The stochastic frontier production function



Source: Coelli, Rao & Battese (1998), p.186

Assuming diminishing returns to scale for the deterministic production function, Figure 3.1 shows two different observable outputs, y_1 produced with the amount x_1 of input and y_2 produced with quantity x_2. The stochastic frontier is not observable, as the symmetric error term is not known, and is given by the junction of the different input/output combination points. It is possible to note that the approach is much more flexible, allowing for various shapes of the production function, which depend on firm characteristics.

The second crucial assumption that has to be made about ε_i is that the u_i are distributed independently from the v_i terms. In their seminal work the authors assumed a half normal distribution (Aigner et al. 1977):

$$u = |U|, \text{ and } U \sim N(0, s_u^2)\text{; i.i.d.} \qquad (9)$$

but they allow for other possible symmetric forms, such as the exponential, quite frequently used in following studies, and the Gamma[26].

Whatever the distribution of u_i, it is possible to observe that when $s_v^2 = 0$ the frontier is equal to the one estimated with the deterministic methodology; while when $s_u^2 = 0$ there is no inefficiency and the production function will be purely stochastic. Hence, the use of two error terms allows for the existence of two different sources of firm efficiency, one of which is under its control, and another which it is not possible to analyse and mainly contains unavailable information[27]. In fact, the v-error can be the result of external events such as luck, climate, machine failure, but it can also represent a measurement error (Aigner et al. 1977). Nevertheless, even if the u-term is assumed to depend on the plant's behaviour, it does not mean that it is possible to control for all its determinants. In fact, part of the (in)efficiency term will include characteristics of the factories that depend on tacit knowledge, which is not available to the researcher. As well indicated by Nelson and Winter (1982) in the first instance, and enlarged on in the following 'neo-schumpeterian' literature, broadly speaking they comprise its routines[28] and historical path[29]. In practice, it is likely that two equal plants, established in the same locality, which use exactly the same mix of input, would achieve different outcomes. In fact, they will differ in how they combine the inputs, not just because of external conditions (such as those captured by the v-term) but on account of plant routines, entrepreneurial decision-making, expectations, and the like[30]. The investigation of those determinants is beyond the scope of the present paper, but we will take them into account when interpreting the results. Above all, we consider the possibility of relaxing the assumption of a unique frontier as already a step forward in the methodological and conceptual approach.

Another advantage of using the stochastic frontier instead of the deterministic one is that it allows the use of Maximum Likelihood Estimates (MLE) that are consistent and asymptotically efficient. This was a strong limitation in the deterministic context, as the asymptotic properties are not assured except when the error is assumed to be distributed with a Gamma density function, which is clearly a strong constraint (Førsund et al. 1980).

3.2. Inefficiency distribution and estimation

Since the main scope of this analysis is to understand the determinants of the inefficiency and how they differ across sectors and plants, the distribution assumptions of the u_i term in (8) are of crucial importance. We know that the term has to be positively distributed, but assuming any specification on its more general distribution is in a way like answering what the efficiency looks like before having estimated it. Choosing the wrong distribution might even bias the results. Hence we adopt the more flexible form, which is a truncated-normal, as a generalisation of the half-normal distribution in equation (9) (Stevenson 1980). In fact the truncated-normal is obtained by a truncation at zero of a normal distribution, with mean μ and variance σ^2_u;

$$u = |U|, \text{ and } U \sim N(m_i, s_u^2) \qquad (10)$$

[26] We leave the discussion of the distribution of the error term to later as it is a fundamental characteristic of the methodology adopted here.

[27] It follows from this argument that the assumption of independence of the two error terms, while plausible in certain cases, might be unrealistic in others. In fact, it is likely that some of the inefficiencies depend on the unobservables. To our knowledge there is still no econometric technique that can relax this hypothesis, assumed for statistical reasons.

[28] "A routine can be defined as a mechanical operation partly based on tacit knowledge, which does not imply the need for decisions" (translated from Malerba 1982, p 270). It is basically a pattern of repeated action that is well established inside the plant(firm) and does not need major decision-making every time its context is encountered, unless it is changed (Nelson and Winter 1982). The economies in decision-making however come at the price of outcomes which will not necessarily be optimal when the context changes slightly.

[29] Making an extreme simplification, those concepts are based on the idea that the firm is a complex unit of production and that knowledge is not defined as available information (as in Arrow 1962) but as a complex set of tacit and codified elements that not always can be translated into information (Winter 1987).

[30] The concept is easily explained borrowing a well-known example. Two cooks preparing a cake with exactly the same recipe, in the same kitchen, at the same time, using two equal ovens, will not bake exactly the same cake.

Clearly, when the mean is equal to zero, the distribution is like the half-normal one, but now the mean is allowed to change and is estimated together with the other parameters of the model by MLE.

The second shortcoming of the stochastic model as defined above is that the two error terms are assumed to be independently and *identically* distributed, and independent one from another. The weakness appears when we aim at understanding how the efficiency of the firms changes according to their idiosyncratic characteristics. This actually implies that the u_i are not identically distributed (Coelli et al. 1998). Hence, estimating the effect of firm-specific variables in a second step, using the predicted mean efficiency, seems inconsistent with the assumption of the independence of the u-terms made in first instance. The problem has been solved by modelling an estimating procedure and a likelihood function that allow the mean of the truncated-normal to change according to the values of the determinants of efficiency. A one-step procedure has been adopted in which the mean of the distribution is estimated as a function of independent variables, together with the other parameters, providing more efficient estimates (Coelli 1996).

Hence, the inefficiency term u_i for the i^{th} firm is obtained with a truncation of the normal distribution with mean μ and variance σ^2_u where the mean depends on a vector of explanatory variables (Battese and Coelli 1993);

$$u = |U|, \text{ and } U \sim N\left(\delta_0 + \sum_{k=1}^{M} \delta_k z_{ki} + \omega_i, \sigma_u^2\right), \quad \omega_i \geq -\delta_k z_{ki} \tag{11}$$

where the random variable ω_i defined by the truncation of the normal distribution can be both positive and negative when $z_{ki} > 0$, and is independently but not identically distributed, z_{ki} is a vector of determinants of firm efficiency, and δ_k a vector of coefficients that are estimated.

Again, it is possible to observe that the model allows for three special cases: i) when all the δ_κ parameters and σ^2_u are equal to zero the model is equivalent to an average response model and OLS estimates are efficient; ii) when all the δ_κ parameters except δ_0 are equal to zero, the model is equal to the first specification with a truncated-normal distribution given by equations (7) (8) and (10); finally, when all the δ parameters, including δ_0 are equal to zero, the model is defined as in equations (7) (8) and (9) (Coelli et al. 1998).

3.3. Econometric software and the estimation process

The likelihood function for the MLE of the model defined by equations (7) (8) and (11) has been derived by Battese and Coelli (1993), and is shown in the appendix A.1[31]. Two parameterisations of the variance terms σ^2_v and σ^2_u have been used to define it and are particularly useful in the estimation process. $\sigma^2 = \sigma_u^2 + \sigma_v^2$ is the total variance and $\gamma = \sigma_u^2 / \sigma^2$ is the ratio of the variance of the efficiency term to the total variance, which lies between zero and one (Battese and Corra 1977). A high value of γ indicates that most of the variation of the frontier is due to inefficiency (γ=1 gives the deterministic frontier model), while a value which tends to zero indicates that stochastic disturbances prevail.

Using the stochastic framework, the predicted measure of technical efficiency indicated in equation (6) changes. In fact, we can only observe the total error term $\hat{\varepsilon}_i$ given the values of the estimated parameters $\hat{\beta}_i$,[32] but we have to estimate its decomposition in the two different terms u_i and v_i. A solution was found which suggested considering the expected value of u_i conditional on ε_i (Jondrow et al. 1982). In the present

[31] For its derivation and the expressions of the density functions refer to the appendix of the original paper (Battese and Coelli 1993).

[32] From equation (7): $\varepsilon_i = \ln(y_i) - \beta_0 - \sum_{i=1}^{n} \beta_i x_i$

work we use a predictor of the efficiency that is a modification of the original one, which is derived from the following starting equation (Battese and Coelli 1988):

$$E\hat{F}F_i = E\left[\exp\left(-u_i\right) | e_i = \hat{e}_i\right] \tag{12}$$

where ε is defined in equation (8) and $\hat{e}$ is its estimated value. Its expression is shown in the Appendix A.1, while we address the interested reader to the appendix of the original paper for the complete derivation.

To our knowledge, the only econometric package that allows for the one-stage estimation of the parameters of the production frontier and the parameters of the distribution of the (in)efficiency 'error' term is the Frontier version 4.1 (Coelli 1996). The constraint is that the programme is quite limited in its options (mainly for testing) and allows for the estimation of only one model at a time[33].

The programme follows the following three-step estimating procedure (Coelli 1996). In the first step it estimates the parameters of the production function with OLS, providing unbiased estimators except for the constant term β_0 and the total variance σ^2. Hence, the coefficients are unbiased but not efficient. In the second step a value of γ is provided through a two-phase grid search using the OLS estimation for the unbiased parameters β_i, and corrected OLS ones for the constant β_0 and the variance σ^2.[34] Finally, the values chosen during the grid search are used as starting values for the iterative process which leads to the MLE when it converges[35]. The procedure has been constructed in order to facilitate convergence, using a parameterisation of γ that lies between one and zero.

The programme provides outputs for the OLS estimates of the production function parameters, and the ML estimates for all coefficients ($\hat{b}_i$ and $\hat{d}_i$), variances ($\hat{g}$ and $\hat{s}^2$), value of the log-likelihood function and the firm efficiencies (EFF_i).

3.4. The production function

We now have to define the functional relation among the inputs used for the production (X_i) and the output (Y_i) they generate. The choice is of particular importance, as different specifications can generate different outcomes in estimating the frontier. In particular, the most widely used production function, the Cobb-Douglas (CD), assumes constant output elasticities with respect to inputs, constant returns to scale and unitary elasticities of substitution among the inputs. Given a two-input production function:

$$Y = f(X_i);\ i = 1,2 \tag{13}$$

output elasticities are defined as:

$$a_i = \frac{\partial Y}{\partial X_i}\frac{X_i}{Y}; \tag{14}$$

returns to scale are defined as:

$$RTS = \sum_i a_i;\ \text{and} \tag{15}$$

and the elasticity of substitution for two inputs is defined as:

[33] It is based on MS-DOS programming.
[34] For an explanation on how the grid search is conducted refer to the programme guide (Coelli 1996).
[35] Given the complex expressions of the likelihood function's partial derivatives, the programmer has chosen the Davidson-Fletcher-Powell Quasi-Newton method, as it does not require the computation of the second partial derivatives matrix.

$$h_{(X_1,X_2)} = \frac{d(X_1/X_2)(X_2/X_1)}{d(f_2/f_1)(f_1/f_2)}\Big|_{Y=cons\tan t} \qquad (16)$$

where $f_i = \partial Y / \partial X_i$ is the marginal productivity of the i[th] good (Griliches and Ringstad 1971, Chapter 2).

As in the present study we compare the efficiency of firms in different sectors that have been divided according to their expected characteristics, we prefer to allow the production function frontier to change as much as possible according to the data used. Thus, we relax all the CD hypotheses, allowing for positive (or negative) returns to scale and different shapes of the isoquants, which will depend both on input proportions and on their scale (non-homothetic production functions). In the first case we allow for sectors in which an increase in the use of inputs increases (decreases) the production at a higher rate[36]. In the second case we allow for sectors in which input can be more easily substituted ($h \to \infty$), while in others they might be strictly complementary ($h \to 0$).

A similar production function was first derived as a second-order Taylor approximation of a CES (Constant Elasticity of Substitution) logarithmic function with two inputs (Griliches and Ringstad 1971). Afterwards it was generalised to the Transcendental Logarithmic Production Function (translog), for multi-products and multi-inputs cases (Berndt and Christensen 1973; Christensen et al. 1973), which can be seen as the second-order approximation of any unknown production function (Greene 2000).

Using the above notation it is expressed as (Greene 2000):

$$\ln Y = b_0 + \sum_{k=1}^{n} b_k \ln X_k + \frac{1}{2}\sum_{k=1}^{n}\sum_{l=1}^{n} b_{kl} \ln X_k \ln X_l + e \qquad (17)$$

It may be noted that when the product and cross-product elements β_{kl} are equal to zero the function is equal to a CD in a log-linear form.

The advantage of using the more flexible form is that is allows for both linear and quadratic terms. The shortcomings of the above formulation in the estimation process are collinearity and degrees of freedom limitation problems (Coelli et al. 1998). Given the magnitude of our sample the latter is not a problem in the present work.

4. DATA, VARIABLE DESCRIPTION AND MODEL

Using the stochastic frontier approach, we estimate the production function of plants in nine different manufacturing sectors at two-digit level, across firms in different regions and municipalities. In the present section we introduce the sectoral classification, describe the data and denote the indicators selected and used.

4.1. Sector classification rationale

Sectors have been grouped into nine categories using the International Standard Industrial Classification (ISIC) employing both revision 2 and 3. In the appendix we present the composition of the groups with a synthetic description and reference to their correspondence in the ISIC (table A.2). The nine classes have been defined according to their use of nationally available natural resources, and their degree of technological complexity. Limitations on the achievable level of disaggregation clearly cause some overlapping of the two characteristics across categories, as some sectors might be both based on natural resources and using advanced technological processes. We take into account this limitation when interpreting the results, addressing the different industrial composition of the categories where they may be significantly affected.

[36] Using the same notation, there are increasing returns to scale when: $f(tX_i) > tf(X_i)$

While the use of natural resources might be easily identified, the technological categorisation seems more blurry. According to the theoretical framework presented in chapter 2, there are two main advantages in specialising in industries with high technological density: it reduces the ratio of domestic to foreign income elasticity, and it generates a process of knowledge accumulation. Nevertheless, before describing the composition of the categories, we need to show how goods can be classified according to their extent of technological intensity and whether it relates to international market dynamics.

On the first issue, one of the most well known classifications is the Pavitt taxonomy (1984), which distinguishes among supplier dominated (SD), specialised suppliers (SS), scale intensive (SI) and science based (SB) sectors . Firms in the different categories are differentiated for their ratio of used and produced technology[37]. Even if in our framework this distinction is of fundamental importance, the taxonomy has been built on the British industrial sector, and a direct use in developing countries could be unfortunate[38]. The main problem would be in the different processes that firms in the same sector would use in the different countries.

Even so, the Pavitt taxonomy has been subsequently used to build classifications more suited to developing countries (e.g. Ferraz et al. 1996; Lall 2000). In the present study we adopt the classification developed by Ferraz et al., which was constructed for the analysis of the Brazilian industrial sector, and has been used in different works on Latin American countries' industrial evolution and competitiveness (e.g. CEPAL 2002; Yoguel 2000). The taxonomy accounts for both firms' input demand and output characteristics, and is divided into: commodities, durable, traditional and high technology (technology diffusers). It can be noted that the categories look quite similar to Pavitt's. Yet, industries and sectors were included also by observing the local process and product characteristics.

Concerning the relations with the export market, Lall has shown that the more technological industries[39] are those that have relatively increased their importance in international trade. The only exception are some traditional goods, because of the relocation of production toward countries abundant in unskilled labour. "The largest and most successful exporters in the world specialise in High Technology and Medium Technology products and […] specialisation in High Technology products is increasingly related to export success" (Lall 2000, p.21).

Nevertheless, the concept of technological complexity remains quite variable and difficult to analyse even inside one industry, and the shortcoming becomes clearly more serious when aggregating at two or more digit level. Yet, we make the simplification that we can differentiate technological content of sectors at four digit level using the 'Ferraz taxonomy' (Ferraz et al. 1996), and we observe that within the classification adopted, 'durable' and the 'technological diffusers' goods are concentrated in S7 and partially in S4 and S6 (table A.8) All other plants are mainly concentrated in traditional or commodities industries. While the Ferraz taxonomy is built only with a technological content perspective, we made an effort to separate the sectors also according to their use of natural resources, the main comparative advantage of Chilean economy. Thus, we can briefly describe the selected sectors as follows.
S1: contains those industries that use mainly traditional processes[40] and that are intensive in the use of natural food-based primary resources, included fish processing, a comparative advantage of Chile. Hence,

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[37] We address the interest reader to the original article for the definition and comprehensive description of each sector. Very briefly, the first category SD applies to traditional industries, that do not innovate and use machine embodied technology; SS are both technology suppliers and users, e.g., machinery producers; SI firms are mainly in durable goods production, both use and produce technology but in a more 'formal' way than SS (e.g. R&D); SB are more technology suppliers than users where R&D is a basic element of production (e.g. some chemicals producers, electronics) (Pavitt 1984).

[38] To our knowledge, the taxonomy has been directly applied to developing countries only in a study of the Mexican industrial sector (Dutrénit and Capdevielle 1993).

[39] Classified again on the basis of Pavitt taxonomy and the technological categorisation designed and adopted by the Organisation for Economic Co-operation and Development (OECD) (Hatzichronoglou 1997).

[40] According to the Ferraz taxonomy, though some food-based industries might use very advanced processes, with high knowledge content.

while according to Ferraz they are mainly traditional producers, in our view they are commodity producers with traditional technologies.
S2: all the industries commonly referred to as traditional ones; no particular reference to commodities and comparative advantages.
S3, S8 and S9 are all industries based on wood processing, which represent another comparative advantage of the Chilean economy. They are divided into three different sectors as they use quite different transformation processes, where in S8 and S9 they are more technology-intensive.
S4: mainly production of plastic products and basic chemicals. The sector incorporates quite different processes with some technologically advanced industries and no particular use of local natural resources.
S5: production based on local mineral resources, the third main comparative advantage of Chile. Final products have on average quite low technological content.
S6: most of the production is traditional and based on local mineral resources, but some of the plants produce durable goods.
S7: the most advanced sector with plants that produce 'durable' and 'technological diffusers' goods. Not based on local comparative advantages, mainly exploiting knowledge and technological assets.

4.2. Data sources and variable selection

4.2.1. Data

For the main analysis we draw the data from the plant level survey known as ENIA[41] carried out by the Chilean Statistical Institute (INE – Istituto Nacional de Estadistica) in the manufacturing sector, in the years 1996 and 1997. The survey is conducted on all firms registered at a fiscal level with more than 10 employees (INE 1999). Thus, we cannot account for micro enterprises and for all informal manufacturing, although the two categories tend to overlap. This limitation might cause a selection bias, but to our knowledge there are no industrial surveys that account for firms with less than ten employees. Thus, on the basis of the previous studies conducted on firm surveys, we assume there is no bias without testing it formally.

The time series is limited to a two-year period as information on the municipal location of plants was available for these years. Given the two years are consecutive, we have decided to pool the data into one single period in order to double the available sample. Most of the plants are thus reported in both years, but they enter the database as different units of observation. Inflation should not be a concern as it applies to both input and output variables, without affecting the estimation of the production function.

For the elaboration of some of the local variables we have used the household survey conducted by the Planning and Co-operation Ministry (MIDEPLAN – Ministerio de Cooperacion y Planificacion). The Encuesta Nacional CASEN (Encuesta de Caracterización Socioeconómica Nacional)[42] used was held in 1998 on 48,107 households, of which one third were from rural areas and two thirds from urban areas, for a total sample of 188,360 observations (source: CASEN, 1998). The period mismatch between the industrial survey and the household one is due mainly to two factors: i) the 1998 CASEN database had a bigger and more representative sample; and ii) it has been already used in previous research on households, providing a tested reliability, and better defined variables. Nevertheless, it has been used as a source for the construction of variables that have very small changes in the short run. We have tested its characteristics, where possible, comparing average data between 1996 and 1998 surveys. No major differences appear and we assume they are due to the use of a bigger sample for 1998.

For some of the local variables we have referred to other national Chilean sources that provided aggregated data. They are directly mentioned in the description of the variables.

[41] ENIA: Encuesta Nacional Industrial Anual (National Industrial Annual Survey).
[42] Survey on the Socio-economic National Characterisation. http://www.mideplan.cl/sitio/Sitio/casen/htm/casen.htm

4.2.2. Production function variables

This section reports the variables used in the production function, together with a brief description of their construction and selection methodology[43]. A more handy list of variables with a brief description is provided in the appendix (table A.1).

Dependent variable (Y): From the firm survey we have computed the gross output and the value-added, both extensively used in the literature surveyed. With the latter, material inputs are accounted for 'asymmetrically' (Griliches and Ringstad 1971). Using the translog function it has the advantage of eliminating one of the dependent variables from the left-hand side, reducing the problems of collinearity. However in our sample a consistent number of plants reported negative values for this value-added variable, which would have made the log transformation impossible. Thus, in order to avoid a selection bias due to the dropping of non-positive values, we have opted for the gross output (thousand of Chilean pesos). Computation of gross output includes VAT.

Materials (M): Total acquisition of primary resources and other materials directly involved in the production process, including inputs acquired from other plants of the same firm, expressed in thousands of Chilean pesos, and including VAT.

Labour (EMPLEO): Total number of workers, including owners, managers, specialised workers, administrative staff, sellers on commission, non-qualified workers and services. We have preferred the number of workers instead of the employment costs, as we did not have adequate information on the plant accounting methodologies. Outworkers are not included as we do not have information on the number of hours worked and their skill level, and their expansion and contraction are more subject to problems of endogeneity.

Capital (ELECTR): Initially we computed the capital stock as $K_t = (1-t)K_{t-1} + I_t$, where τ is the depreciation index, and I the new investment. By doing so, we had problems in understanding how the values had been accounted and reported by the plants, as many observations with new investment had contemporaneously zero capital assets (before accounting for depreciation). Besides, we compared plants with zero capital in both 1996 and 1997, and most of them invested in the first year. Finally, comparing the consumption of electricity and the capital stock, almost all the plants with no capital reported had a positive and high electricity consumption. To avoid a misinterpretation of the data, and the dropping of all those observations with zero capital assets, we decided to use electricity consumption as a proxy for capital input. This choice has the disadvantage of increasing the endogeneity problem, but it has the great advantage of providing a better understanding of the real utilisation of capital by the plant. In fact, the existence of capital stock does not give any information on whether it is actually involved in the production process.

4.2.3. Efficiency variables: plant characteristics

Determinants of efficiency have been divided into plant characteristics and local development indicators. The first have been built using the ENIA industrial survey, and differ across factories. The latter have been constructed using different sources and refer to characteristics of the municipality or region in which the plant has been established[44].

[43] Variable name in parentheses reports the names as presented in the results table.

[44] We discuss here the use only of those variables that have been introduced in the final model. Results from other specifications along with variable descriptions are available from the author. The other variables tested at the firm level were: exports, a dummy for the Ferraz category, a dummy for exporting firms and the machinery investment ratio; at the municipal level: literacy rate, index of mathematics tests on students; at the regional level: ratio of trained workers, population, percentage of poor, income distribution index (Gini), credit market (proxied by number of bank branches), telephone lines p/c, average municipal income, average municipal transfer from central government, government expenditure, number of PhDs, area of forests, length of coasts, mine concessions, mine GDP, ratio of skilled workers, ratio of managers. We do not have here the space to discuss all the theoretical and empirical issues that led to the final model.

The first two variables that model the efficiency distribution refer to the form of ownership of the plant. The majority are national and private, hence we wanted to control for the effect that public and foreign ownership might have.

Majority of foreign ownership (FORMAJ): A dummy variable that is equal to one when the majority of the plant is owned by foreigners and zero if majority is national. It is expected that foreign companies are more efficient than the national ones, given their access to technologies, markets, capital, etc., even though we will not analyse the direction of causality. The aim of the variable is to control for factors that characterise foreign firms whose effect might be absorbed by other indicators if the dummy is not introduced. Hence, it will be considered more as an indicator of firm efficiency than a determinant.

Public ownership (PUB): A dummy variable that is equal to one when the plant is in public ownership and zero when it is private. Public enterprises might have a strategic role in the industry, or might indicate the presence of natural monopolies. Public firms are often considered to be less efficient than private ones. The aim of the present work is not to analyse this particular aspect, but as in the previous case, public ownership might account for information and characteristics for which we want to control.

Import of inputs (IMP): A dummy variable that is equal to one when the plant imports part of the material inputs, and zero otherwise. The scope of this variable is to understand to what extent the Chilean industrial sector is dependent on foreign inputs to upgrade its productivity and how it change across sectors. We expect a positive effect on efficiency, higher in the more advanced sectors.

Ratio of male workers (LMALE): Percentage of males in the total plant workforce. The database clearly indicates that there is a large majority of male workers, even if the extent changes across sectors (table A.18). It could be the case that in some of them a shift in gender proportions changes the relative level of efficiency, even though the result might not have a purely economic explanation.

Ratio of managers (LMANAG): Percentage of managers in total plant workforce. The variable accounts both for the owners and employed managers as a ratio of total employees. Most of the plants have either one or the other, except some plants that might be owned by another firm. Although there is not much variance in our sample (plants with 5 or more managers are 11% of the total), a high ratio of managers could represent those firms that have complex organisational systems. In theory we expect a positive impact on efficiency, but interpretation of the results is limited by not having the possibility of controlling for the quality of the management.

Ratio of skilled workers (LSKILL): Percentage of skilled workers in total employees. Following most of the previous empirical work we have included specialised workers and administrative staff. As for the previous variable we do not have data to control for the level and quality of skills. The inclusion of administrative staff in the same category is useful to distinguish it from the residual unskilled labour force. The variable is important as it proxies for the complexity of the production, in terms of products and processes. A quick overview of the descriptive tables in the appendix clearly indicates that the most traditional sectors have a lower average and median ratio of skilled workers (table A.16). In theory we expect a positive effect on efficiency, but the same limitations as for the manager ratio apply in the interpretation.

Concentration index (CI): Ratio of the proportion of a sector in a region compared to the importance of the same sector in the whole country. The index, borrowed from Lall and Rodrigo (2001), captures whether plants in a sector are more concentrated in a specific area than in the total economy.

$$CI_{S,R} = \frac{\sum Empleo_{S,R} \Big/ \sum Empleo_{R}}{\sum Empleo_{S} \Big/ \sum Empleo}\ , \tag{18}$$

where *Empleo* is defined as in the production function (number of employees), S is the sector and R the region. The index has a value greater than one when the size of sector S with respect to total manufacturing is higher in region R than the Chilean average[45]. The index has been constructed using a sectoral disaggregation at two-digit level (ISIC rev. 3). The CI is meant to capture whether plants gain in efficiency when concentrated in a region where other plants of the same sector have been established.

There are various reasons why this might be the case. In the case of commodity industries, we might think that most of the plants wish to localise where the primary resource is available (static comparative advantage). This effect will be greater when the transportation costs of the resource, due to infrastructure development or its characteristics, are high (Krugman 1995). The same concept can apply to non-commodity sectors, where the attraction is no more the presence of static natural endowments but the establishment of services and infrastructures that render the plant's activity less costly (created competitive assets). While those effects can be captured looking at the presence of both natural and 'generated' endowments, plants of the same sector might also concentrate due to the presence of externalities. For example, we might think of Marshallian passive externalities such as specialised markets for labour, large demands for suppliers, and the possibility to exchange information (or even knowledge) (Marshall 1920).

The adopted index for CI does not allow for understanding more 'complex' frameworks such as the one delineated in the established literature on industrial districts and local milieux (e.g. Camagni 1991; Piore and Sabel 1984), as it accounts for the concentration of each sector separately. The industrial district analysis would go beyond the aims of the present research and would need a higher level of sectoral disaggregation and understanding of the local industrial structure.

We do not expect any particular sign of the coefficients of the CI as, depending on the sector, there might be both positive and negative externalities, and it might capture different advantages or disadvantages. Using again the example of the resource-based sectors, we might for instance expect that, in some of them, the high concentration spoils the natural resource, generating negative congestion effects.

Firm size (LNEMPLEO): The variable is the same as used in the production function. Used as a determinant of the efficiency distribution, we want to control for differences among different sizes. In theory we would expect that large firms are more efficient as they can exploit economies of scale, have better access to markets (imports, exports, credit, labour, etc.), are privileged by many industrial policies, and have more opportunities to react to external shocks. Nevertheless, those factors might impact differently according to the sector analysed, and they might be more or less important. Moreover, Small and Medium Enterprises (SMEs) might have other advantages in terms of flexibility, reduced sunk costs, or greater co-operation opportunities (e.g. Piore and Sabel 1984). Hence, we expect a positive impact of size in sectors characterised by economies of scale but we have no expectations for the other cases.

4.2.4. Efficiency variables: local development indicators

The last group of variables contains various indicators of local development and endowments at a municipal or regional level, depending on the availability of data. The latter vary across 13 regions, while we have information for 243 municipalities[46].

Size of local workforce (LWORKF): The logarithm of the total number of people of the right age and condition to work in the municipality. We have constructed the variable using the Chilean household survey (CASEN), in order to control for the size of the locality. Given that we are dealing with plants, we preferred to use this indicator instead of the more often used value of the total population. The variable is important for two different reasons. In the first instance we control for the effect that the local industrial concentration can have on average economic activity, and public funding and investment (which are variables in our model). Second, it can be compared with the results of the CI providing a more complete interpretation on whether plants gain (lose) from localising where firms of the same sector are present or where economic activity in general is intense (Lall and Rodrigo 2001). Recalling the natural resources example, it might be the case that plants suffer negative externalities from the presence of others exploiting the same asset, but take advantage

[45] We have not normalised the index as it has only one digit values, being five the highest one.
[46] Clearly not all sectors are present in all regions or municipalities. The variable is attached to all firms located in the same region/municipality.

of the externalities that spill over from factories in other sectors. In theory, we would expect that agglomeration has a positive impact, but the interplay with the CI might give different results.

Rate of unemployment (RUNEMP): Percentage of unemployed in the workforce of the right age and condition to work in the municipality; computed from the household survey. The variable both controls for whether the total workforce is the effective measure of economic activity, and proxies for the local level of economic activity. Moreover, unemployment might affect plant efficiency in a number of different respects, such as working incentives or skills. Yet, the direct effects of unemployment on efficiency should be taken cautiously as in small municipalities the estimate might suffer from endogeneity. In fact, plants might increase (decrease) their activity for reasons not related to unemployment, but in turn their investment decision will clearly affect employment.

Average years of school (LSCHOOL): Logarithm of the average number of years the population has spent in formal education in the municipality; computed from the household survey. Education is considered a crucial factor to boost industrialisation in more advanced and competitive sectors, as it increases the ability to innovate and adapt production to new technologies, speeding up the process of diffusion (Nelson and Phelps 1966). In fact, several authors have argued that educational policies have been at the basis of the rapid industrialisation of the south-east Asian Newly Industrialised Countries (NICs) (e.g. Kim 1997).

Average wages (LWAGEAV): Logarithm of the average monthly wages in Chilean pesos in the municipality, computed from the household survey. We use the wage variable also as a proxy of the ratio of skilled people in the locality, as the plant database indicates that wages paid to skilled employees and managers[47] are double those paid to unskilled workers. We expect a positive impact on firm efficiency.

Public investment (LPUBI): Logarithm of public investment per region in the period 1990-1997 in millions of US dollars[48]. We use a value for the past seven years because public investment does not generally have a short-term effect. The impact on firm efficiency depends on whether the public investment crowds in or crowds out private investment, and this too might vary across sectors.

Kilometres of road per capita (LKMPC): Logarithm of the number of square kilometres of road per inhabitant in the region in 1996.[49] To simplify the model and limit collinearity problems we had to choose only one proxy for infrastructure, and this was the one chosen. A positive impact on efficiency is expected.

Technological funding (LTECFUND): Logarithm of the total technological funds received by research institutions and firms in the region in 1996 in thousands of Chilean pesos.[50] We do not use a per capita measure as funds are directly given to institutions and firms to co-finance research and innovative projects[51]. We do not have the information to attach the funding directly to the firms in our sample, but the variable proxies regional R&D activities. We expect a positive impact, mainly in the more advanced sectors.

4.3. Estimated model and sample

Given the econometric approach (chapter 3), the form of the production function (section 3.4) and the dependent and independent variables (section 4.2), the final model we estimate is the following:

[47] The database reports the figure for wage payments to an aggregate class that includes managers, specialised workers and administrative.

[48] Source: Chilean Economic Ministry, Division of Productive Development, http://www.economia.cl

[49] Source: 'Informe de Competitividad Regional' (Regional Competitiveness Document), Ministerio-del-Interior 2000, based on Dirección de Viabilidad / INE (Board of Traffic Regulation / National Statistical Bureau).

[50] Sources: FONTEC, FONDECYT, FONDEF; respectively Fondo Nacional de Desarrollo Tecnologico y Productivo (National Fund of technological and Productive Development), Fondo de Educación Superior y Desarrollo Cientifico y Tecnológico (Fund for Higher Education and Scientific and Technological Development) Fondo de Fomento al Desarrollo Científico y Tecnológico (Fund for the Promotion of Scientific and Technological Development).

[51] Refer respectively to http://www.corfo.cl ; http://www.conicyt.cl ; http://www.fondef.cl

$$\ln Y_{ij} = b_0 + b_1 \ln EMPLEO_{ij} + b_2 \ln M_{ij} + b_3 \ln ELECTR_{ij} + b_4 \ln EM_{ij} \cdot \ln EL_{ij} + b_5 \ln EM_{ij} \cdot \ln M_{ij}$$
$$+ b_6 \ln M_{ij} \cdot \ln EL_{ij} + b_7 \left(\frac{1}{2} \ln^2 EMPLEO_{ij} \right) + b_8 \left(\frac{1}{2} \ln^2 M_{ij} \right) + b_9 \left(\frac{1}{2} \ln^2 ELECTR_{ij} \right) + v_{iv} - u_{ij} \tag{19}$$

$v_{ij} \overset{iid}{\sim} N(0, s_v^2)$ and

$u_{ij} = | U | \; and U \overset{id}{\sim} N(m_{ij}, s_u^2)$

where:

$$m_{ij} = d_0 + d_1 Formal_{ij} + d_2 Pub_{ij-1} + d_3 \operatorname{Im} p_{ij} + d_4 Lmale_{ij} + d_5 Lmanag_{ij} + d_6 Lskill_{ij} + d_7 Ci_{ij} + d_8 Lempleo_{ij}$$
$$+ d_9 Lworkf_{ij} + d_{10} Runemp_{ij} + d_{11} Lschool_{ij} + d_{12} Lwageav_{ij} + d_{13} Lpubi_{ij} + d_{14} Lkmpc_{ij} + d_{15} Ltecfund_{ij} + w_{ij} \tag{20}$$

where ω_{ij} defined as in equation (10); i = 1,…n is the number of observations per sector; and j = 1,...9 are the sectors as defined in section 4.1 above.

Elasticities of inputs in the production function (19) are now defined by equations (21), (22) and (22), at the mean values of the log of the input quantities[52]:

$$\frac{\partial \ln Y}{\partial \ln EMPLEO} = b_1 + b_4 \overline{\ln ELECTR} + b_5 \overline{\ln M} + b_7 \overline{\ln EMPLEO} \tag{21}$$

$$\frac{\partial \ln Y}{\partial \ln M} = b_2 + b_5 \overline{\ln EMPLEO} + b_6 \overline{\ln ELECTR} + b_8 \overline{\ln M} \tag{22}$$

$$\frac{\partial \ln Y}{\partial \ln ELECTR} = b_3 + b_4 \overline{\ln EMPLEO} + b_6 \overline{\ln M} + b_9 \overline{\ln ELECTR} \tag{23}$$

We pool the surveys of the two available years, obtaining a total sample of 10,713 plants divided into the nine sectors[53]. We do not account for the sector including ‘other manufacturing firms’, as their number is very small and we are not interested in analysing firms we cannot classify. This first selection reduces the total sample by 168 firms, without clearly affecting the sectoral samples, which are the ones we estimate.

We then proceed by dropping the observations for which input variables have a zero value, as they cannot be transformed into logarithms. In particular, there is one observation with gross output equal to zero, one with employment equal to zero, plus four with employment less than 10. The latter are not accounted for in the estimated sample as the survey is meant to include plants with more than 10 employees, and we assume those four are measurement errors. The number of observations with a zero value for material inputs is 10. Finally 77 firms appear to have zero consumption of electricity. Dropping those observations is less a problem than the much higher number that have a value of capital equal to zero, as plants that do not use electricity around the whole year presumably do not operate. Our assumption is confirmed by the fact that those firms are the same as those with zero output, zero employment and part of the zero material acquisition. Hence, the final number dropped amounts to 89 observations. The sample used for OLS estimation and only plant characteristics thus accounts for 10,456 observations divided into 9 sectors.

[52] Note that square terms enter divided by two in the estimated equation.
[53] The size of sectoral samples, with a brief description of the sectors, are reported in the appendix in table A.2.

Lastly, the inclusion of municipal indicators in the final model requires the dropping of a few more observations, depending on the coverage of the household survey. This sample includes 10,006 plants, divided into the nine sectors. We summarise the sectoral sample and dropped percentages in the appendix, table A.2.

5. ESTIMATION AND ANALYSIS OF RESULTS

We first estimate the production function on its own, without controlling for efficiency. Then, using the methodologies described in chapter 3 we contemporaneously introduce the determinants of its distance from the efficiency frontier. Those are divided into firm characteristics and local characteristics, with the latter, depending on the available data, referring to the regional or municipal level. Thus, we test for the optimal model that fits each sector, and analyse the results.

5.1. The Production function and diagnostic analysis

Before starting the analysis of the final model, we regress using simple OLS the production function in each sector, in order to test for elasticities, returns to scale, error skewness and diagnostics[54]. From an empirical point of view, using the stochastic frontier model we are more interested in analysing the efficiency of the firms and its determinants than the production function frontier itself, which is more an instrument[55]. Theoretically, the OLS estimates of the parameters of the production function are consistent, apart from the constant term and the variance (refer to chapter 3), even if they are not efficient.

Even before running the regressions, we graphically analyse the relations between outputs and the single inputs[56] (figures A.1 – A.2). We mainly want to check whether there are outliers or influential points that could distort the results. We consider there is no relevant element which suggests eliminating data, as different tests indicate different possible outliers. Hence, any observation dropping would be an arbitrary choice that could itself bias the estimations. In most of the cases the sample is large enough to make any possible outlier not influential, while in those sectors which have smaller samples (S8 and S9), there is no evidence of possible outliers.

Plots indicate that the relation between input material and gross output is more direct than the relation between output and, respectively, labour and capital. In all the sectors the first input looks the least dispersed, followed by labour, with capital being the more variable. The same results are confirmed by pairwaise correlation coefficients[57].

As expected, all R-squares are very high, but in most of the sectors some of the regressors are not significant. This appears to be due to the presence of the expected high collinearity in the model[58], which renders t-tests unreliable. Hence, to verify whether the use of the translog is consistent and preferred to a restricted version such as the Cobb-Douglas, we test the probability that all the second-order terms are contemporaneously

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[54] The Frontier 4.1 software does not allow for much analysis of the results nor for any diagnostic test, hence we prefer to check them on the simple production function before starting the estimation with the stochastic frontier approach, with a more flexible software.

[55] Ideally the aim would be to compute directly the values of the inefficiency terms, but we have to compute them through the estimation of the frontier production function (see chapter 3). Hence this kind of analysis conceptually differs from the usual econometric estimation as the error is the centre of the attention and not the collector of all missing information (Greene 2000).

[56] Plots are based on the sample reduced to the availability of municipal indicators; yet a comparison with the full samples has been conducted, in which no substantive differences appear. The plots for only two sectors are presented in the Appendix, one with a large sample and one with a small sample. All other sectors look quite similar, available from the author.

[57] Results are not inserted to save space, but are available from the author.

[58] Given the structure of the Translog (refer to chapter 3) all the inputs enter the production function more than once. A computation of the Variance Inflation Factor (VIF) in fact results in very high values, which are even higher for the sectors with smaller samples.

equal to zero using a Likelihood Ratio test (LR)[59]. In none of the sectors is the null hypothesis of the Cobb-Douglas restriction accepted. In any case, differences in total returns to scale as between the two different specifications are never very large, and in some sectors the null hypothesis of equality is accepted.[60] Nor has the sign of this difference a unique direction, although the cases in which the translog estimates higher returns to scale are more frequent than with the Cobb-Douglas function.

Given that we allow for the presence of two different error terms, with different distributions, we are not concerned by non-normal errors and their non-constant variance. On the contrary, as we allow the distribution of one of the errors to vary according to the firm's characteristics, we assume that the presence of heteroskedasticity is due to this variation, while v_i terms are homoskedastic. As expected, the errors are much more concentrated around their means in the regressions run in each sector than in regressions comparing all manufacturing industries, confirming that it is necessary to control for their different production processes and that the classification adopted accounts for fairly homogeneous industries[61].

Given our expectation on the distributional form of (in)efficiency, we would suppose that total error terms ε_i are more concentrated on the left (negative) side of the distribution. An overview of the Kernel density estimates and frequency distributions (figures A.3, A.4) seems to confirm this tendency, but in most sectors not really in a striking way. Nevertheless, we check for the medians of the error terms and in all the sectors they are negative[62], but even in this case the values are very low (zero up to the first or second decimal digit). Hence, while the fact that all distributions tend to the normal respects the MLE hypothesis[63], we bear in mind that some of the inefficiency effects might turn up as non-significant.

This point is extremely important and needs a brief digression. In fact, it has been demonstrated that, given the LL function defined by Aigner et al. (1977), if the inefficiency terms are assumed to be normally distributed (non-negative), their variance is bigger than zero if and only if the third moment of the total residuals is negative (Waldman 1982). In the other case, the LL has its local maximum corresponding to $\gamma = 0$, (i.e. the OLS estimates are the parameters that maximise the LL). Hence, there is no evidence of inefficiency and MLEs do not provide different values of the parameters. Yet, this result is not valid asymptotically (Waldman 1982) and, to our knowledge, when the inefficiency δ parameters are introduced[64]. The sample in most sectors is quite large. Nevertheless, we test whether in some of them we can accept the hypothesis that the efficiency determinants δ_i are equal to zero and the u_i are distributed with a truncated normal (equation (10)) (table 5.4). In this case we should test for skewness of the residuals. The hypothesis is rejected in all sectors[65].

In the last instance the distribution of ε_i depends on how large is the stochastic term variance σ^2_v, compared with the variance of the inefficiency term σ^2_u[66].

5.2. Estimation with efficiency indicators

We next introduce the firm efficiency indicators and data at municipal and regional level. Due to some missing values at the municipal level, the sample is reduced by dropping the firms of the corresponding

[59] Given that this is not our final model, but is only used to check for the robustness of the production function, we do not report result tests, which are instead reported for the final model. They are however available from the author.
[60] For the sake of comparison with the final results the translog elasticities are reported in the appendix in tables A.4 – A.7. Cobb-Douglas elasticities are available from the author.
[61] Measures of Kurtosis are much higher for the total sample than for sectoral samples, apart from S1 and S4 that have a less homogeneous composition.
[62] Providing the expected information that there are more errors on the negative side.
[63] It is assumed that the errors are independent of one another and the sample covers almost all the manufacturing plants in their sector.
[64] We have not found any study that derives the value of the LL and its changes around the point where $\gamma = 0$, in the case of the specification used in our work. The introduction of a new parameter used to maximise the LL would change the conditions demonstrated by Waldman.
[65] Test is not provided for S9 because, as we explain in the following paragraph, we accept the hypothesis that there are no inefficiencies at all in that sector.
[66] As mentioned in section 3, when $\sigma^2_u \rightarrow 0$, also $\gamma \rightarrow 0$.

municipalities, as already noted. It could be the case that those localities coincide with the more underdeveloped ones (e.g. we keep all the observations in the metropolitan region around Santiago), although in some cases the percentage of dropped observations is very small (table A.2). A comparison of the returns to scale and elasticities among the complete and reduced sample shows that, apart from one case (S3), there are differences only starting from the third decimal digit (tables A.4 – A.7). Moreover, the evidence is mixed, with some sectors in which the returns to scale are slightly higher in the reduced sample and others in which the complete sample estimates lower results. In the case of the third sector the selection is more sensible (12% of the observations are dropped), and the elasticities are a little bit lower in the reduced sample; we will take this into account in evaluating the results.

Before the definition of the final model illustrated in chapter 4, we tried different specifications inserting various local indicators across the sectors, in order to induce empirically the more significant variables and control for the largest number of determinants. The definition used here is the result of an effort aimed at contemporaneously limiting problems of collinearity while capturing all the possible information through different proxies. The selected variables are also the more robust ones as their changes across specification were low.

We have avoided the use of clearly endogenous variables such as regional GDP, exports and foreign direct investment (FDI). Without having the possibility to control for the direction of causality it would have been quite difficult to give any reliable interpretation of their coefficients[67].

We provide the results for the estimates of the best available model in table 5.2. In the first place we analyse their reliability, testing i) whether the translog specification for the production function is better than the Cobb-Douglas; ii) whether the use of local indicators is significant or everything is explained by plant-level factors; and iii) whether there is an inefficiency error term at all, or everything is explained by random error (table 5.4). All the hypotheses have been tested through a likelihood ratio test (LR), as it has been previously demonstrated to have the correct size (contrary to a Wald test) (Coelli 1995). While the first two tests are ordinarily distributed with a χ^2_{df}, the last investigates the value of the parameter at its lower limit. It has been demonstrated that in this case the LR has an asymptotic distribution that is a mixture of χ^2 (Coelli 1995).

The first test is rejected for all sectors, concluding that the Cobb-Douglas restriction would fit worse than the translog. Hence, even if some of the input coefficients appear not significant using the t-test[68] (table A.3), they actually help to explain input elasticities[69]. The second test is accepted only in the case of S2, providing some information that for traditional, labour-intensive manufacturing (with no particular link to the primary sector) there is no efficiency gain in the location decision, when can be attributed to local endowments. Conversely, in the other sectors local variables play a role in explaining firm efficiency.

The last test is accepted only for S9, for which the model is clearly misspecified, given the values of the log-likelihood function (LL). Hence, in this last sector either there are no (in)efficiency effects, or it is not possible to distinguish them from stochastic errors[70].

To conclude, we will use the model with both plant and local efficiency determinants in all sectors apart from S2 and S9. In the first case there are inefficient plants but their distance from the frontier is not determined by local factors, hence we interpret the results that include only firm indicators (table 5.3). In the latter case there is no evidence of an inefficiency term, hence we comment only on the elasticities, but the sector is clearly dropped in the discussion of the determinants of efficiency.

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[67] We would not be that surprised in discovering that firms in high exporting areas are more efficient than those where there is no access to export markets. Without time series information and a proper control for self-selection of firms, it would be impossible to assert which phenomenon influences the other one.

[68] We have already mentioned the problem of unreliability of the t-tests in the presence of collinearity.

[69] As the value of elasticities is not computable straightforward from estimated coefficients, we insert in Appendix the results for the only final model applicable to each sector. The other results are available from the author.

[70] In this case we have reported the results of the test for the production function obtained with OLS: the Cobb-Douglas is rejected. It is interesting to mention that the error distribution in the paper sector, estimated with OLS, has the closest median to the zero average among all sectors (figure A.5), confirming the correlation between the distribution of errors and the accounting of inefficiencies.

5.2.1. Some results

Results of the estimated input elasticities, measured at their mean values, are presented in table 5.1. In all sectors input materials have a very high elasticity, which is even higher in those mostly dependent on primary (local) resources such as food commodities, wood and paper products, and manufacture of basic mineral products. The second common pattern is the very low returns to capital, while labour estimates have quite standard values, apart from two very low cases. Those results suggest that, across all sectors, Chilean manufacture is mainly based on the available materials, while a small part of the value-added comes from capital usage. Labour returns appear to be higher in those sectors where more skilled workers are used, but are very low in the traditional sector (S2) which is meant to be labour-intensive, and in the mineral-based sector (S5), where it is expected that production is based on resources and fixed capital investment[71].

Table 5.1 – Input elasticities (according to model selected per sector)

Input / Sector	L	K	M	TRS
S1	0.470	0.081	0.719	1.270
S2[a]	0.075	0.073	0.634	0.782
S3	0.230	0.072	0.715	1.018
S4	0.363	0.048	0.627	1.039
S5	0.073	0.120	0.654	0.847
S6	0.334	0.053	0.591	0.978
S7	0.438	0.092	0.571	1.101
S8	0.583	0.026	0.559	1.168
S9 OLS[b]	0.233	0.102	0.709	1.044

[a] Estimation obtained without local determinants and plant efficiency effects
[b] Estimations obtained with the translog function with entire sample (N = 230), and no (in)efficiency effect
Notes: L is labour input, K capital input, M material inputs, and TRS total returns to scale.

Since our main interest is in the efficiency of plants and its determinants, we present estimates for the roles of regional and firm indicators in table 5.2, and for the latter only, in table 5.3. The tables also report the mean efficiency, but due to the problematic interpretation of the average value we present in the Appendix more tables with values on the efficiency distributions, per sector and per region (tables A.19 – A.29). Figures for the estimated Kernel density distributions are also presented in Appendix (figures A.7 – A.14). Even if previous studies have compared efficiency across sectors, we agree with Coelli et al. (1998) that we should be very cautious in such a comparison. In fact, we recall that the (in)efficiency measures obtained are relative to the frontier estimated for each sector. A strict comparison of values would implicitly assume that all the sectors have the same production frontier, which is not realistic, and definitely not supported by the data[72]. In order to compare efficiencies, attempts have been made to model the concept of the metaproduction function[73] (Hayami and Ruttan 1970) with the stochastic production frontier approach. But it has been used to compare efficiency in the same sector across regions and not vice-versa (Battese and Rao 2001).

Taking into account those considerations, we can still observe that the traditional sector (S2), that of manufactures based on primary mineral resources (S5), and the publishing and printing sector (S8) have the

[71] The two sectors are respectively the least and the most capital intensive (table A.13)
[72] We have already mentioned that the error term variance is much lower in the sectoral regressions than in the total. Moreover we test the restriction of pooling the data in one sample with LR on the OLS estimates (as the final model estimated is different across sectors), where the test has the following form: H_0: $\beta_{i1} = \ldots = \beta_{i9}$, where i = 0,…9 are the input variables and the second digit represents the nine sectors. Results of the test: unrestricted LL = 2471.788; restricted LL = 3508.752; $\lambda = 2073.928 \sim \chi^2_{80}$. We do not have the available related critical value, but with 50 df it is 63.17, which implies that the hypothesis of equality would be rejected.
[73] Assuming that all the producers in different regions have access to the same technologies, the metaproduction function is defined as the "envelope of the production points of the most efficient" regions (Battese and Rao 2001), p.1.

highest number of inefficient firms relative to the Chilean[74] sectoral respective frontiers (table A.19 and figures A.19 – A.29). The remaining sectors have fairly similar distributions, with two sectors partly differing; i) food commodity producers (S1) are more dispersed and some are relatively very inefficient, and ii) the chemical and plastic sector (S4) has a lower median, as the higher density corresponds to relatively inefficient firms.

Given those preliminary considerations, we are now interested in analysing which are the significant determinants of efficiency in the different sectors, and whether there is any space for industrial policy to increase the efficiency of the most dynamic ones. We first notice that the local variables, when controlling for plant characteristics, have little or no relevance in affecting the efficiency of the plants. Partly this is due to the low variability of the local data in comparison to plant data. Some of the local regressors change according to municipalities, but some change only according to regions. In addition, in most sectors the majority of the factories are concentrated in the metropolitan region, and sometimes in a few others (table A.10), which reduces even more the variability[75]. Nevertheless, the fact that plants concentrate in a few regions is an indicator that the local endowments might play an important role. In fact, we have regressed the same model using only the local indicators, and most of them turned out significant[76]. This could mean that local dynamic assets such as access to skilled labour, concentration, available inputs, access to imports, etc., affect firm efficiency indirectly, through plant characteristics. Plants mainly cluster in the Metropolitan region, where non-natural assets are concentrated. Only the wood manufacturers (for the more basic industries in S3) highly concentrate around their natural resource, and the mineral production (S5) to a much less extent. Other resource-based sectors (S1, S6, S8, S9), do not show a clear pattern (tables A.9, A.10). The fact that the region around the capital Santiago is also the one that provides great part of the 'dynamic assets' and no static comparative advantages (Ministerio-del-Interior 2000), is a first indicator of the important role of the first endowments in plant locating strategies.

We now proceed to evaluate the results of the estimations. Majority of foreign ownership in the plants is significant in only two sectors, with a positive impact[77]. Not surprisingly these are sectors having the highest proportion of foreign ownership and of large plants, which shows that foreign investments were involved where large capitals are needed and economies of scale could be exploited (S4 and S5 are also the most capital-intensive sectors). The pattern is confirmed by the high presence of factories with majority foreign ownership in the paper sector (not included in the efficiency analysis), and the concentration of foreign ownership in plants of bigger size in food commodities (where the effect is positive but not significant). However, an understanding of FDI impact on local firm efficiency across sectors would require a deeper analysis, considering that there might be a strong selection bias, as it is likely that foreign companies invest in more efficient plants (Aitken and Harrison 1999). It is interesting to note that our data confirm that most FDI is concentrated in commodity industries (table A13) (Benavente et al. 1998), aimed at the exploitation of local natural resources advantages. Even if we are not able to say much about the direction of causality, we can note that in five out of seven sectors, FDI does not have significant impact on relative plant efficiency. These results confirm that the main gains derive from the high capital investment, but that there are no major technology or knowledge transfers that would improve the productivity of the firms. A recent work on the determinants of innovation in Chilean plants shows that FDI has a positive role in adopting new tools, improving product design and reorganising the administrative organisation (assuming there is no self-selection bias); but it has no significant role in innovation in products and in packaging, and does not increase the probability of having an R&D laboratory and acquiring foreign licences (Alvarez and Robertson 2000). This analysis was conducted using a reduced sample of the same survey as ours, but with no sector differentiation and only on large firms (the average plant has 302 employees).

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[74] Note also that we do not have any information on 'international best practice', which would be again necessary to compare efficiency across sectors. In fact, even assuming we can conclude that one sector is more efficient than another, it might not be the case relative to the international frontier for the respective sectors.

[75] Note that S2, for which model with local indicators has been rejected, is the most concentrated in region 13 (table A.10).

[76] More indicators than those used in the final model have been used with significant results. They were not included for reasons of space and because, due to misspecification, they are not interpretable. They are available from the author.

[77] It is probably worth recalling that the u_i are inefficiency measures, and the reported variables affect positively (negatively) the inefficiency (efficiency) when the coefficient is positive.

Table 5.2 – Estimates: firm efficiency and local development indicators model

Variable	Sector	S1	S2	S3	S4[b]	S5	S6	S7	S8	S9
Const	δ_0	-2.901**	4.638**	-0.151	0.800	6.472	-0.263	0.661	4.041	2.208*
		(-2.840)[a]	(4.766)	(-0.179)	(1.440)	(0.302)	(-0.234)	(0.624)	(0.020)	(1.893)
Formaj	δ_1	-0.046	0.042	-0.034	-0.112**	-0.167**	0.066	-1.038	0.032	0.052
		(-0.828)	(0.461)	(-0.369)	(-3.281)	(-2.173)	(0.584)	(-1.420)	(0.259)	(0.708)
Pub	δ_2	0.316	-0.009	0.074	-0.198**	-0.371**	0.671**	0.495**	0.204	--[c]
		(1.023)	(-0.026)	(0.391)	(-2.697)	(-4.103)	(3.464)	(2.253)	(1.469)	
Imp	δ_3	-0.080**	-0.180**	-0.269**	-0.133**	-0.002	-0.143**	-0.189**	-0.227**	-0.036
		(-2.118)	(-4.855)	(-13.30)	(-4.956)	(-0.057)	(-2.971)	(-2.645)	(-4.048)	(-0.714)
Lmale	δ_4	-0.677**	-0.119**	0.019	-0.067	-0.213*	0.165	-0.158	0.000	-0.308**
		(-8.766)	(-2.862)	(0.270)	(-0.958)	(-1.894)	(0.984)	(-0.825)	(0.000)	(-2.341)
Lmanag	δ_5	-0.766	-0.105	0.033	-0.060	-0.184	0.398	-0.725	-0.122	-0.915**
		(-1.176)	(-0.717)	(0.109)	(-0.290)	(-0.784)	(1.451)	(-1.546)	(-0.489)	(-2.583)
Lskill	δ_6	-0.156**	-0.065**	-0.054	-0.392**	-0.202**	-0.149**	-0.231**	-0.220**	-0.082
		(-2.792)	(-2.227)	(-1.134)	(-4.086)	(-3.672)	(-2.475)	(-2.452)	(-4.369)	(-1.107)
Ci	δ_7	-0.014	0.057	-0.008	-0.042	-0.039**	-0.144**	-0.409**	0.117**	0.083
		(-0.452)	(0.522)	(-0.301)	(-0.553)	(-2.407)	(-2.761)	(-2.790)	(1.978)	(0.820)
Lempleo	δ_8	0.817**	-0.327**	-0.044**	-0.011	-0.196**	-0.106**	-0.019	0.047	-0.287**
		(2.792)	(-5.268)	(-2.689)	(-0.478)	(-3.217)	(-2.959)	(-0.365)	(0.001)	(-4.452)
Lworkf	δ_9	-0.029	0.006	-0.006	0.031*	-0.009	-0.027	-0.014	-0.103**	-0.004
		(-1.193)	(0.253)	(-0.274)	(1.788)	(-0.448)	(-0.926)	(-0.365)	(-2.571)	(-0.145)
Runemp	δ_{10}	0.736	-0.863	0.601	-1.577**	0.177	0.263	-1.016	0.383	0.648
		(1.308)	(-0.568)	(1.625)	(-2.726)	(0.308)	(0.441)	(-1.042)	(0.452)	(0.770)
Lschool	δ_{11}	0.004	0.347	-0.048	0.077	0.290	0.460	-0.191	0.606	-0.258
		(0.013)	(0.942)	(-0.237)	(0.367)	(0.960)	(1.166)	(-0.456)	(1.373)	(-0.543)
Lwageav	δ_{12}	-0.022	-0.228**	-0.027	-0.119**	-0.183	-0.152	-0.062	-0.240*	-0.023
		(-0.199)	(-2.046)	(-0.399)	(-2.435)	(-1.536)	(-1.247)	(-0.485)	(-1.878)	(-0.156)
Lpubi	δ_{13}	0.015	-0.212	0.158	0.147**	-0.355**	0.351**	0.081	-0.027	0.261
		(0.225)	(-1.305)	(1.614)	(3.877)	(-3.779)	(3.337)	(0.525)	(-0.232)	(1.057)
Lkmpc	δ_{14}	-0.132**	-0.066	-0.101	-0.076	-0.041	-0.139**	-0.212**	-0.077	-0.071
		(-3.391)	(-0.998)	(-1.212)	(-0.887)	(-0.910)	(-2.668)	(-2.132)	(-1.398)	(-0.723)
Ltecfund	δ_{15}	0.024	0.071	-0.049	-0.038	0.138**	-0.111**	0.095	-0.010	-0.082
		(0.823)	(0.870)	(-1.584)	(-0.683)	(3.215)	(-2.427)	(1.374)	(-0.158)	(-1.048)
γ		0.605**	0.484**	0.011**	0.007	0.596	0.086	0.347**	0.294	1.000**
		(18.948)	(8.024)	(3.585)	(0.696)	(0.118)	(0.958)	(2.305)	(0.009)	(33.674)
σ^2		0.147**	0.094**	0.076**	0.129**	0.104**	0.087**	0.142**	0.079**	0.058**
		(15.748)	(19.864)	(19.587)	(19.131)	(17.368)	(13.818)	(6.213)	(13.906)	(11.227)
Mean eff.		0.822	0.670	0.868	0.808	0.122	0.865	0.823	0.276	0.295
LL OLS		-564.873	-378.283	-174.405	-498.206	-209.964	-193.786	-354.855	-88.057	-9.359
LL MLE		-408.604	-295.837	-139.261	-447.533	-170.988	-157.894	-315.334	-56.900	3.290
N		2946	1832	1066	1144	599	871	945	375	228
Model used		YES	NO	YES	YES	YES	YES	YES	YES	NO

[a] Number in parenthesis are the respective t-ratio. Coefficients reported with ** are significant at 95% level, * at 90% level.
[b] Estimation of sector 4 with local indicators had to be done providing starting values for the iteration process, as the usual process of frontier 4.1 was providing a LL function higher for MLE than for OLS. Yet, we have provided exactly the same starting values used by the programme in the usual process, with the exception of γ, which was set equal to its value in the estimation without local indicators; we thus believe that the correction do not influence the results.
[c] Not applicable as there are zero observations with public property.

Public firms represent a very low proportion of the manufacturing sector (table A.13), mainly concentrated in machinery production and elaboration of non-metallic raw materials. Just as for FDI, public ownership is positively correlated with size, as probably referring to those plants that require high fixed investments and have the highest returns to capital (tables 5.1, 5.2). Given the low participation in the sample, the variable is significant only in four sectors, and has a positive effect on efficiency only in two of them, where the main production of public firms is the casting of non-ferrous metals[78] and basic chemicals (source: ENIA 96-97). The fact that they are the same industries where also foreign ownership has a positive role supports our hypothesis that this is mainly due to the exploitation of economies of scale.

On the contrary, public ownership has a negative role in more dynamic sectors such as S6 and S7. Nevertheless, it is not possible to assert in this work whether those firms have a positive role in overall industrial development through other channels, such as investments in R&D, training, materials supplies, etc. For example, it is worth noting that the average ratio of skilled workers across all sectors (without public firms) is 0.28, while the average in public firms is 0.6. Even in S7, that has the highest ratio of skilled workers, in firms owned by the public sector it is double the average (source: ENIA 96-97).

It might be the case that those plants have an important training role for formally educated workers, with a high labour turnover; i.e., they prepare young workers that are then able to shift to the private sector after the training period.

Imports of inputs have a significant positive effect in all sectors apart from S5. The result is not surprising, as it confirms that the major channel of technological improvement across Chilean industries is through machine-embodied knowledge and better quality inputs, both imported from abroad (Alcorta and Peres 1998; Benavente et al. 1998; Cimoli and DiMaio 2002). The evidence underlines that there is a low effort in local industry to produce those inputs which increase firm efficiency, as the plants that have access to import markets are significantly more efficient with respect to those that use national inputs.

The extent of the import coefficient across sectors is quite variable, and does not indicate any precise pattern. The impact is low in S1 where mainly local inputs from the primary sector are used and the transformation technology is mainly a simple one[79]. Imports are not significant in S5, which is strongly based on local natural resources (metallic and non-metallic mines), and which is also the sector with the lowest efficiency distribution (figure A.19). Nonetheless, plants that exploit local forest resources are the most influenced by importing materials (S3 and S8). The high value of the coefficients might indicate that local resources, while important, need complementary assets to render plants efficient. It is telling that it is even more the case in the sector where products and processes are quite low intensive in technology (mainly sawmilling, planning and furniture). Plants in the classes that account for the most advanced sectors (S4 and S7) are strongly positively affected by imports, but not more than average.
The access to imported inputs is one of the variables that might in turn be affected by different local characteristics, such as the access to external markets and the availability of inputs in the local ones. The former is confirmed by the positive correlation among the ratio of imported inputs and both regional public investment and the kilometres of roads per inhabitant, proxy for infrastructural development (tables A.30 – A.39). We do not have enough information to assert anything about the latter condition as we should consider more specifically the characteristics of the subsectors and analyse their production chains.

Another variable that is positively significant across most sectors is the ratio of skilled workers to total workers. The impact is stronger in those sectors where the average and median ratio is higher (S4, S7 and S8) (table A.16), which are also the ones that account for the most advanced subsectors[80]. Across all classes the distribution of the variable has two relative maxima[81], suggesting that most plants in the sector have a

[78] Which represents 70% of the public firms in sector S5 (source: ENIA, 1996-97).
[79] In this particular sector more than half of the plants in the sample estimated are manufacturers of bakery products, of which only 1% import input materials. In fact, 93% of those plants have less than 50 employees (50% less than 20) and most likely are local bakeries. The second group in importance processes and preserves fish and fish products (fish flour), the third are manufacturers of grain mill products (source: ENIA, 1996-97). Hence there is not much evidence that the sector is an advanced agro-industrial one.
[80] Relating industrial classes with Ferraz taxonomy (1996).
[81] One obviously coincides with the absolute maximum, which is the one that corresponds to low values of the variable.

low ratio of skilled workers, but that there is also a considerable number that have a high ratio (figure A.15, A.16). Hence, the less likely situation is to have a relatively similar number of skilled and unskilled workers, which indicates a quite polarised industry.

Those sectors that have the largest average also have the highest proportional number of firms with a 'skill ratio' close to one (table A.16). Assuming we can proxy the level of technological complexity by the number of skilled workers, we could conclude that those sectors have the highest proportion of advanced plants (S4, S6, S7, and S8). But surprisingly, while the machinery sector has a high number of relatively efficient firms, publishing and printing has all its plants quite far from the sectoral frontier. Nevertheless, the results for this second case are biased by the fact that newspaper and periodical publishing represents a considerable part of it[82]. This subsector employs a very high number of skilled workers, among which one third are actually administrative[83]. Hence, in this case the 'skill ratio' is not interpretable as an indicator of 'technological capabilities' in manufacturing, and the subsector itself is more a service than a manufacturing one. To conclude, the above results on the skill ratio confirm our hypothesis that the availability of a skilled workforce increases the competitiveness of the industrial sector. They have a positive impact on the efficiency of its plants, mainly in the more dynamic sectors, but also in more traditional labour-intensive ones, where the unskilled labour force plays the major role.

The ratio of skilled employees is also likely to be strongly influenced by local factors, such as the degree of education, number of educational institutions, average economic conditions, labour mobility, and wages. Concerning the variables that we have included in our model, the skill ratio is positively correlated with the average local wages and years of schooling in nearly all sectors (tables A.30 – A.39). Those results suggest that the most advanced firms, which are those that are more strongly affected by having a high number of skilled workers, tend to locate in areas where there is a large supply of educated people and are prepared to pay them a higher salary.

On the contrary, the number of managers relative to workers does not represent a significant variable for efficiency. A higher number of managers should suggest that a plant has a more complex organisation, but lack of information on managerial quality and skill level limits the analysis of this variable. Nevertheless, this result might be evidence for the fact that the managerial structure of Chilean plants is not competitive, and does not enhance their efficiency. It has been argued that corporate management had a crucial role in determining countries' competitiveness, but that at the same time it is not easy to imitate (such as technological knowledge). Concerning the region we are dealing with, Fagerberg et al. (1994, p.14) argue that "attempts to graft leading-edge practice into a different sociocultural setting, as for example by Latin American countries adopting North American managerial practices, have been much less successful" than developing corporate strategies built on local social capabilities.

As indicated in table A.18 all the sectors employ a large majority of male workers, with the partial exception of the traditional sector. Yet, they positively affect efficiency at a 95% significance level only in two of them.

Controlling for plant size results in a significant determinant of efficiency in many sectors. The first striking result is that in food commodities manufacturing (S1) small and medium enterprises (SMEs) are much more efficient than large ones. Although the coefficient reduces by ten times when the bakeries are removed from the sample[84], it is an important result in terms of policy implications. Yet, in all other sectors larger firms are also the more efficient, even if it is not significant in those that are meant to account for the most technologically advanced industries, S4 and S7. Overall these estimates suggest that the role of SMEs has to be taken into account in the Chilean economy as potential competitive producers, probably excluding those sectors where high fixed investments and sunk costs are required, such as S5 and S6. Our results are in line with previous studies of SMEs in the country, which have stated that even if large firms are, on average,

[82] Almost all the largest firms of class S8 are classified as periodical and newspaper publishing (source: ENIA, 1996-97).
[83] We recall that our skilled variable is the sum of specialised workers and administrative staff. According to the complete firm survey, the average number of specialised workers and administratives in the newspaper subsectors is around, respectively, eight and six times the manufacturing average (source: ENIA, 96-97).
[84] Results not inserted are available from the author.

more efficient, SMEs are reducing the labour productivity differential and have played an important role in the last decade in the industrial sector (Peres and Stumpo 2000)[85]. Nevertheless, it is much less the case in the traditional sector, where SMEs are what have suffered most from the structural reforms (Katz 2001), and apparently are not recovering.

The concentration index (CI) is a relative measure that shows whether a particular sector (classified at 2-digit level) is more concentrated in one particular region than in the country as a whole. In the first instance we note how its significance changes when local indicators are introduced or excluded, showing its high correlation with them (tables A.30 – A.39). The CI proxies for the effect that agglomeration forces can have on efficiency, in terms of positive or negative externalities. Our estimates provide some mixed results across sectors. It is not significant in those that are based on natural resources and have technologically simple processes of production, such as food and beverages, and wood manufacture (S1 and S3). The result is quite surprising, as S3 is the sector with the highest percentage of plants concentrated in the region where the resource is most present (tables A.9 and A.10). On the other hand, in those sectors based on natural resources but with higher investments in capital required, such as metal and non-metal manufacture (S5 and S6), CI has a positive effect, although not strong. It is expected that part of the gain is due to the local presence of natural resources. Yet, the ratio of plants located in the regions where the number of mine exploitation concessions is high is quite low. On the contrary, most of the plants concentrate in the Metropolitan Region. Thus, gains from assets present in the region around Santiago should be higher than resource transportation costs. The outcome is positive also in the most traditional industries (S2), where the advantage does not derive from the presence of local resources, but more from the generation of positive externalities. We recall that for the present sector we accept the model with only plant efficiency indicators. It is likely that the concentration index retains some of the information that is not explained by the regional indicators. The correlation matrix of the sector in fact indicates that the index is highly positively correlated with infrastructures, public investment, percentage of technological funds, average wages and years of schooling. This pattern actually recalls more a Krugman approach (Krugman 1995) to localisation with cumulative causation effects than the Marshallian one (Marshall 1920).

Finally, plants in the machinery sector gain strongly by concentrating. In the absence of any particular linkage with the primary sector, and controlling for local factors[86], it is likely that those plants gain from spillover effects. Thus, in this case, it appears that Marshallian externalities play the strongest role. We do not have enough information to analyse the sources of externalities, which could be the outcome both of other factories' activities and of public efforts in research and development.

The impact of sectoral concentration has been controlled with total industrial concentration, proxied by the total number of workers in each municipality. In fact there might exist externalities both within the same sector and across sectors, in terms of producer-supplier relationships (Lundvall 1988). Besides, while the concentration index might proxy for factors related to spillovers and externalities, the industrial density accounts more for the cumulative process of infrastructure development, and concentration of new industries. However, this latter effect seems to be not significant, apart from two cases. Concerning the printing industries, we estimate that the sectoral concentration generates negative externalities that reduce plant efficiency, while localising in areas with higher industrial density has a positive influence. A correct explanation of those results requires a much more disaggregated analysis on the specific subsectors which goes beyond the purposes of the present work. In all other industrial classes, the size of the workforce has a positive but non-significant effect, except in the chemical and plastic sector where it has a negative impact but significant only at the ten per cent level.

To conclude, our evidence suggests that plants tend to gain more in efficiency by concentrating on non-natural assets than where natural endowments are located. In the only case in which there is a significant correlation between resource concentration and plant concentration (S3) (tables A.9 and A.10), the CI is not significant. This last phenomenon might be explained by the presence of congestion effects around forest resources, which counterbalance possible positive externalities. Contrary to the other commodity sectors, assets that might be present in the Metropolitan region do not overcome the transportation costs of wood.

[85] Likewise, programmes aimed at the amelioration of SME competitiveness based on co-operative strategies (PROFOs - Programas de Fomento), have been evaluated as having a positive impact (Benavente et al. 1997).
[86] Correlation among CI and the local variables are much less strong than in the previous case S2.

Partly this is due to the average smaller size of plants, and partly to the lower technological content of the wood-manufacturing sector.

As previously mentioned, the direct role of local variables in plant efficiency is weak. The rate of unemployment is a positive determinant for chemical plants, a result that is coherent with the negative effect of the workforce density on the sector, but which is quite unexpected. One possible explanation is the fear effect that unemployment has on occupied workers, one of the arguments at the basis of efficiency wage labour models[87]. The main idea is that employed workers, at a given wage, will put more effort into their job if there is the possibility of being fired and the probability of reemployment is reduced by the increase of unemployment. But, here again, the analysis would be quite simplistic without studying in greater depth the sectoral characteristics and the relations with local employment.

The average number of years of schooling is not significant, but it is likely to have an indirect effect through the supply of skilled workers. Nevertheless, the fact that only the latter appears significantly positive in our estimations confirms the hypothesis that the supply of education is not sufficient. Formal education has to be applied to learning processes to generate a pool of skilled and productive workers that increase local industrial competitiveness (Lall 2000). The absence of demand for skills can result in a high rate of brain drain. The concentration on low dynamic sectors with low technological intensity, and the consequent total reliance on the import of technology through capital goods, generates this outcome. Finally, a relevant reason might also be that the variable used is not disaggregated to control for vocational education, which in theory can have a stronger direct impact on the localisation strategies of the plants. Also positively correlated with the skilled workers ratio is the average wage, which has a significant positive effect on efficiency in two sectors, chemicals and printing (at 90% s.l.). We might think of a recursive effect, as plants pay higher salaries in order to obtain higher results in terms of labour productivity, which will raise the average wage rate in the locality but also average labour productivity. Hence, newly established firms will have to be efficient enough to pay the average wage, but will also be able to exploit a labour market with high returns. This could generate an auto-selection process and local economies of scale conceptually very near the Marshallian labour externalities (Marshall 1920). In any case, it is clear that the plants tend to gain from an increase in the wages and not from exploiting cheap labour.

The last three regional variables are highly intercorrelated, as they all represent public policy outcomes, even if in very different aspects. To some extent the correlation might cause a problem of collinearity. Hence, among the several specifications tested, we excluded public investment from the regressors, but with no major change in most of the sectors. Thus, our estimates indicate a crowding-out effect of public investment in two sectors while a positive effect is present in the sector most based on mineral resources. The ratio of technological funds produces the opposite result, as they positively affect plants that are negatively affected by general public investment and vice-versa. In particular, the sectors affected significantly are both based on mineral resources, S5 and S6. However, the former deals with very basic rough material processing, while the plants in S6 produce more elaborated products that require more complex processes. Plants in S5 on average reduce their efficiency when technological funds are assigned to the region in the place of general public investment, while the opposite happens in the latter sector. This might indicate that more advanced factories take advantage of the shift from general investment to provision of funds that enhance R&D activities, while the less competitive ones gain from public investment that appears to be a general subsidy to an endowment which is considered strategic[88], but is actually not dynamic. Finally, infrastructures significantly increase plant efficiency in three sectors, with the strongest impact in the most advanced one (S7), which has a straightforward interpretation.

[87] For a brief and interesting survey refer to Yellen (1984).
[88] Recall that firms in S5 also gain from public ownership.

Table 5.3 – Estimates: firm efficiency indicators model

Variable	Sector	S1	S2	S3	S4	S5	S6	S7	S8	S9
Const	δ_0	-2.792**	2.004**	1.271**	1.192**	2.337	0.234	0.874**	2.534	2.473**
		(-11.04)	(7.190)	(4.815)	(3.159)	(0.041)	(0.595)	(3.765)	(0.189)	(3.923)
Formaj	δ_1	-0.041	0.077	-0.066	-0.092	-0.170**	0.384*	-1.461	0.082	0.207**
		(-0.800)	(0.943)	(-0.487)	(-1.403)	(-2.255)	(1.888)	(-1.527)	(0.925)	(2.074)
Pub	δ_2	0.315	0.003	0.264	-0.725*	-0.375**	1.111**	0.364**	0.171	--[b]
		(1.389)	(0.008)	(1.004)	(-1.690)	(-4.410)	(2.652)	(2.664)	(0.669)	
Imp	δ_3	-0.102**	-0.170**	-0.486**	-0.170**	-0.027	-0.541**	-0.253**	-0.210**	-0.179**
		(-2.890)	(-5.724)	(-4.828)	(-4.062)	(-0.812)	(-2.393)	(-2.464)	(-3.735)	(-2.298)
Lmale	δ_4	-0.655**	-0.108**	0.021	-0.141	-0.160	0.913*	-0.066	-0.096	-0.239
		(-9.689)	(-2.965)	(0.176)	(-1.564)	(-1.522)	(1.788)	(-0.367)	(-0.814)	(-1.435)
Lmanag	δ_5	-0.550	-0.109	0.053	0.096	-0.160	1.862**	-0.942*	-0.227	-1.167**
		(-1.086)	(-0.956)	(0.207)	(0.342)	(-0.700)	(2.652)	(-1.661)	(-0.756)	(-2.753)
Lskill	δ_6	-0.162**	-0.067**	-0.115	-0.366**	-0.221**	-0.242**	-0.313**	-0.243**	-0.153
		(-2.798)	(-2.324)	(-1.551)	(-3.717)	(-4.151)	(-2.109)	(-3.092)	(-3.176)	(-1.484)
Ci	δ_7	0.047**	-0.103**	0.043**	-0.075	-0.002	-0.484**	-0.381**	-0.020	0.159
		(2.485)	(-3.542)	(4.299)	(-1.598)	(-0.196)	(-2.210)	(-4.047)	(-0.278)	(1.384)
Lempleo	δ_8	0.777**	-0.369**	-0.330**	-0.147*	-0.193	-0.287**	-0.061	-0.210	-0.529**
		(13.464)	(-6.010)	(-4.969)	(-1.652)	(-0.041)	(-2.029)	(-1.036)	(-0.118)	(-3.751)
γ		0.586**	0.500**	0.314**	0.141**	0.046	0.562**	0.440**	1.000**	0.512**
		(20.061)	(8.465)	(5.516)	(3.590)	(0.006)	(3.406)	(3.242)	(916.89)	(5.047)
σ^2		0.141**	0.094**	0.097**	0.140**	0.108**	0.165**	0.164**	0.086**	0.072**
		(18.512)	(22.799)	(23.091)	(19.562)	(17.637)	(3.051)	(5.517)	(4.079)	(8.878)
Mean eff		0.814	0.642	0.797	0.779	0.282	0.881	0.824	0.229	0.740
LL OLS		-618.764	-377.081	-236.552	-503.567	-210.539	-197.996	-356.558	-88.572	-8.821
LL ml		-468.287	-305.069	-209.807	-466.907	-187.529	-172.642	-322.537	-69.712	7.695
N		3199	1837	1216	1156	609	883	950	377	230
Model used		NO	YES	NO	NO	NO	NO	NO	NO	NO

[a] Number in parenthesis are the respective t-ratio. Coefficients reported with ** are significant at 95% level, * at 90% level. [b] Not applicable as there are zero observations with public property.

Table 5.4 – LR tests of hypothesis on the MLEs

Null Hypothesis	Loglikelihood	λ	χ^2 Critical value	Result
Sector 1	**-408.604**			
$H_0: \beta_4=\ldots=\beta_9=0$	-716.414	615.62	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-468.287	119.336	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-564.873	312.538	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-522.762	228.316	25	Reject H_0
Sector 2	**-295.837**			
$H_0: \beta_4=\ldots=\beta_9=0$	-569.089	546.504	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-305.069	12.464	14.07	*Accept H_0*
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-378.283	164.892	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-372.435	153.196	25	Reject H_0
Sector 3	**-139.261**			
$H_0: \beta_4=\ldots=\beta_9=0$	-205.838	133.154	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-209.807	141.092	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-174.405	70.287	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-174.492	70.462	25	Reject H_0
Sector 4	**-447.533**			
$H_0: \beta_4=\ldots=\beta_9=0$	-619.856	344.646	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-466.907	38.748	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-498.206	101.345	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-498.571	102.076	25	Reject H_0
Sector 5	**-170.988**			
$H_0: \beta_4=\ldots=\beta_9=0$	-271.086	200.196	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-187.529	33.082	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-209.964	77.950	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-210.009	78.042	25	Reject H_0
Sector 6	**-157.894**			
$H_0: \beta_4=\ldots=\beta_9=0$	-260.964	206.14	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-172.642	29.496	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-193.786	71.785	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-193.789	71.79	25	Reject H_0
Sector 7	**-315.334**			
$H_0: \beta_4=\ldots=\beta_9=0$	-358.381	86.094	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-322.537	14.406	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-354.855	79.042	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-350.923	71.178	25	Reject H_0
Sector 8	**-56.900**			
$H_0: \beta_4=\ldots=\beta_9=0$	-66.501	19.202	12.59	Reject H_0
$H_0: \delta_9=\ldots=\delta_{15}=0$	-69.712	25.624	14.07	Reject H_0
$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$[a]	-88.057	62.313	26.983	Reject H_0
$H_0: \delta_1=\ldots=\delta_{15}=0$	-88.058	62.316	25	Reject H_0
Sector 9	**3.290**			
$H_0: \beta_4=\ldots=\beta_9=0$	-1.862	--	12.59	--
$H_0: \delta_8=\ldots=\delta_{14}=0$	7.695	--	14.07	--
$H_0: \gamma=\delta_0=\ldots=\delta_{14}=0$[a]	-9.359	25.299	25.689	*Accept H_0*
$H_0: \beta_{4OLS}=\ldots=\beta_{9OLS}=0$[b]	--[c]	18.34	12.59	Reject H_0

[a] Distributed with a mixture of a χ^2 distribution such as $1/2\,c^2_{df-1}+1/2\,c^2_{df}$. Critical value available from Kodde e Palm (1986), p. 1246. [b] Given that the model without inefficiency effect is accepted, we test for the production function in the departing OLS estimates.

Test explanation note:

$H_0: \beta_4=\ldots=\beta_9=0$ cross products and power terms are not significant, Cobb-Douglas production function is preferred.

$H_0: \delta_9=\ldots=\delta_{15}=0$ model with local indicators is not significant.

$H_0: \gamma=\delta_0=\ldots=\delta_{15}=0$ model with inefficiency term γ is not significant (equivalent to $\sigma^2_u=0$).

$H_0: \delta_1=\ldots=\delta_{15}=0$ efficiency indicators are not significant, error term is specified as in equation (6). Note that the constant term is left as the distribution is a truncated normal at any point, not a half normal in 0.

[c] Value of the LR test was directly computed by STATA software.

6. FINAL CONSIDERATIONS

We have made a first attempt to analyse how plant efficiency in a developing country is affected by factors that directly derive from openness and factors that are created by local policies to enhance industrial competitiveness. Given the previous contributions, which directly investigate the relation between export and productivity[89], we consider it a quite straightforward proposition that exporting plants are, on average, also more efficient. Thus, we aimed at understanding which are the determinants that allow factories to be efficient enough to succeed in the export market. Likewise, we considered which policy-induced assets are likely to cause a shift toward more dynamic sectors.

Our estimates have shown a weak explanatory power of local endowments directly on factories, as they appear to have an indirect impact through variables that attach to plant characteristics. Far from been discouraging, it calls for a more attentive analysis on how the latter are in turn affected by different local assets. Nonetheless, the results obtained provide some indications of the importance of policies relative to the often claimed 'miraculous' power of openness, if the industrial competitiveness of Chile has to be raised.

We have estimated a strong dependency of the country on imported materials, which render necessary an export-led strategy to reduce the negative impact on the balance of payments[90]. Yet, as it has been previously showed, the country has taken the opposite path, specialising in sectors with very low technological content and low income elasticity, reducing its terms of trade. Nevertheless, imports are a source of new technology, as confirmed by the overall positive effect they have on firm efficiency. However, the substitution of local technological effort with imported has to be regarded with caution. The non-significance of the supply of educated workers to local plants, together with the marginal role of wages, indicate that the demand for skills is poor and the country is locking into a low growth path, as theoretically described by Krugman (1987). The scenario is confirmed by our estimates of the returns on capital utilisation, which in all sectors are very low. This suggests an inefficient use or a technological backwardness of the machinery, while the material inputs, as mentioned, play the major role.

Contrary to imports, FDI is not as important a carrier of knowledge as it is usually considered, and does not increase the efficiency of the local plants in the advanced sectors. It plays a significant role only where it exploits the main Chilean natural resources (copper and more generally minerals) with capital injections, in sectors where also public factories are more efficient than the national private ones. Whether the technological improvements (if there are any) in these basic industries spill over to the rest of the manufacturing sectors is questionable, and is an important area for future analysis. Our concentration index shows that only in one of the sectors is there a (weak) increase in efficiency from locating near plants producing similar commodities.

Conversely, skills play a major role in manufacturing productivity, increasing the efficiency especially of the most advanced firms. The fact that their impact is stronger than imports confirms the importance of capabilities embodied in workers and suggests their complementarity to the use of imported goods[91]. Likewise, the positive effects of high local wages suggest that at least for two sectors there is no convenience in exploiting cheap labour. It is likely that some firms will gain in cost savings from lower wages, but this will not increase their efficiency, which indicates that the static comparative advantage of cheap labour tends to reduce the country's industrial competitiveness[92].

The concentration patterns of the factories indicate a strong convergence in the regions where the created assets are greater and natural resources lower (barely present), even in the commodity industries (for a ranking of regions according to their endowments refer to Ministerio-del-Interior 2000). The only exception

[89] Often not controlling for most of the variables that might affect plant productivity and are not related to exports.

[90] Our results are in line with the finding by Cimoli and Correa (2002), that report a value of the import elasticity which is two and half times the technological multiplier (the pace at which the country is reducing the technological gap with the international frontier, across all sectors). These results would indicate that the value of exports should increase by the same ratio to positively affect GDP growth.

[91] Note that the increase in the use of imported inputs to total inputs is positively correlated with the increase of skilled workers to total workers.

[92] Note that wages have a positive effect in all sectors, but are actually significant only in two of them.

is the least advanced sector, S3, where concentration per se does not have any impact, but the firms still locate in the region where there is a large presence of forests. However, the sector is also the only one where skilled workers have no impact, indicating its simple production process.

Infrastructure is an another endowment that clearly has a positive impact on efficiency. Estimates on public investment show that there is space for a shift toward more technological funds, which would enhance the efficiency of plants in more dynamic sectors, driving away public resources from endowments that would be exploited anyway, as they represent a comparative advantage.

Overall, the results discussed in chapter 5 leave the answer to the introductory question unaltered. While in some cases openness is an important determinant of plant efficiency, as it increases the level of knowledge inputs, some of the dynamically created assets play a major role in increasing the competitiveness of the factories. Thus, as long as the imports of capital goods are a vehicle for new technology, they enhance the industrialisation process. But when they substitute for local efforts which are not replaced at higher levels of technological intensity, and they substitute for a more efficient use of capital, they hinder long-run growth (the recent recession in Chile might be an example). Finally, following the trade reforms, Chile has been specialising in the production of commodities, due to 'H-O dynamics', and those sectors either have the greatest number of inefficient firms (S5 and S8), or adopt very low technological processes, as proxied by the unimportance of skilled labour (S3).

Conversely, efficient policy intervention is an essential complementary condition, as it can play an important role in increasing plant efficiency through i) skill augmenting, ii) redirecting public investment to technological funds (which also induce a production shift toward more dynamic goods), iii) increasing infrastructures, iv) providing local services that induce the concentration of the most dynamic plants (S6 and S7), which generate positive externalities, and v) counterbalancing the attractions of local endowments, inducing a shift toward higher technology sectors. Far from asserting that local natural endowments have to be ignored, as previously mentioned they have to be exploited to drive the country toward a long-run growth path.

APPENDIX A.1
Mathematical appendix[93]

For simplicity assume the reduced form where variables are in log and all parameters are defined as in the main text (section 3):

$$y_i = x_i b + E_i \qquad (1.A)$$

where

$$E_i = V_i - U_i \qquad (2.A)$$

Expression for the LogLikelihood function used in the estimation of the final model:

$$L(q; y) = -\frac{1}{2}\left\{\ln 2p + \ln s^2\right\} - \frac{1}{2}\sum_{i=1}^{n}\left\{(y_i - x_i b + z_i d)^2 / s^2\right\} - \sum_{i=1}^{n}\left\{\ln \Phi(d_i) - \ln \Phi(d_i^*)\right\} \qquad (3.A)$$

where $s^2 = s_v^2 + s_u^2$ and $g = s_u^2 / s^2$ and,

$$d_i = z_i d / (g s^2)^{1/2}\ ; \qquad (4.A)$$

$$d_i^* = m_i^* / [g(1-g)s^2]^{1/2}\ ; \qquad (5.A)$$

$$m_i^* = (1-g) z_i d - g(y_i - x_i b); \qquad (6.A)$$

$q = (b', d', s^2, g)'$ and $\Phi(\cdot)$represents the distribution function for the standard normal random variable.

Expression for the expected value of the plant efficiency:

$$E(\exp(-U_i)|E_i = \hat{e}_i) = \left\{\exp\left[-m_{*i} + \frac{1}{2}s_*^2\right]\right\}\{\Phi[(m_{*i}/s_*) - s_*]/\Phi(m_{*i}/s_*)\} \qquad (7.A)$$

where

$$m_{*i} = \frac{s_v^2 z_i d - s_u^2 e}{s^2} \text{ and} \qquad (8.A)$$

$$s_*^2 = \frac{s_u^2 s_v^2}{s^2} \qquad (9.A)$$

[93] Based on Battese and Coelli (1993, appendix)

APPENDIX A.2
Variables and sample tables

Table A.1 - Variable description

Var. Name	Coeff	Description	Var. Type	Source
Y		Log of gross output: thousand of Chilean pesos	PF	ENIA, 96-97
Lnempleo	β_1		PF	ENIA, 96-97
Lnm	β_2	Log of material inputs: thousand of Chilean pesos	PF	ENIA, 96-97
Lnelectr	β_3	Log of total electricity consumed: thousand of KwH	PF	ENIA, 96-97
Formaj	δ_1	Dummy for majority of foreign ownership: 0 = foreign property < 50%; 1 = foreign property ≥ 50%	PC	ENIA, 96-97
Pub	δ_2	Dummy for public ownership: 0 = private plant; 1= public plant	PC	ENIA, 96-97
Imp	δ_3	Dummy for the import of material inputs: 0 = the plant do not import any material; 1 = the plant import part of the materials	PC	ENIA, 96-97
Lmale	δ_4	Percentage of male workers over total employees	PC	ENIA, 96-97
Lmanag	δ_5	Percentage of managers over total employees	PC	ENIA, 96-97
Lskill	δ_6	Percentage of skilled workers over total employees	PC	ENIA, 96-97
CI	δ_7	Ratio of the proportion of the sector in a region on the proportion of the same sector in the whole country	PC	ENIA, 96-97
Lnempleo	δ_8	Log of labour input: number of employees as an indicator of plant size	PC	ENIA, 96-97
Lworkf	δ_8	Log of the total number of people in age and condition to work	MI	CASEN 98
Runemp	δ_{10}	Rate of unemployment	MI	CASEN 98
Lschool	δ_{11}	Log of the average years spent in formal education	MI	CASEN 98
Lwageav	δ_{12}	Log of average monthly wages in Chilean pesos	MI	CASEN 98
Lpubi	δ_{13}	Log of public investment since 1990 to 1997 in millions of US$	RI	Ministry of Economy
Lkmpc	δ_{14}	Number of kilometres of road per inhabitant in 1996	RI	MOP / INE
Ltecfund	δ_{15}	Total amount of technological funds given to research institutes and firms in thousands of Chilean pesos	RI	FONTEC FONDECYT, FONDEF

Note: variable types are as follow, PF production function; PC plant characteristic; MI municipal indicator; RI regional indicator.

Table A.2 - Sectorial division used for cross sector analysis

	Description	ISIC Rev3[b] ISIC Rev2	Initial sample	Usable sample[a]	Munic. data[a]
S1	Manufacture of Food, Beverages and Tobacco	15,16 31	3226	3199 (0.84)	2946 (8)
S2	Textile, Wearing Apparel and Leather Industries, traditional industries	17,18,19 32	1853	1837 (0.86)	1832 (0.27)
S3	Manufacture of Wood and Wood Products, Including Furniture,	20,3610 33,34(part)	1227	1216 (0.89)	1066 (12.3)
S4	Manufacture of Chemicals and Chemical, Petroleum, Coal, Rubber and Plastic Products	23,24,25 35	1173	1156 (1.44)	1144 (1)
S5	Manufacture of other non-metallic mineral products and basic metals	26,27 36,37	613	609 (0.82)	599 (1.5)
S6	Manufacture of fabricated metal products, except machinery and equipment	28 38(part)	886	883 (0.43)	871 (1.3)
S7	Manufacture of machinery, equipment, instruments, etc., and vehicles	29,30,31,32, 33,34,35 38(part)	953	950 (0.31)	945 (0.5)
S8	Publishing, printing and reproduction of recorded media	22 34(part)	383	377 (1.57)	375 (0.5)
S9	Paper and paper products	21 34(part)	231	230 (0.43)	228 (0.87)
S0	Other manufacturing sectors	36 (part) 39	168	-	-
Tot	Total manufacturing sectors		10713	10457 (2.3)[c]	10006 (4.3)

[a] In parenthesis the percentage of sample loss.
[b] First and second rows relate to ISIC classification respectively revision 3 and 2. In parenthesis we have indicated 'part' when not all subsectros of the referred ISIC class are included in our classification.
[c] Percentage of total sample loss account for the sector 'other manufacturing' and cannot be interpreted as the average sample loss referred to sectors.
(Source: aouthor elaboration from ENIA database)

APPENDIX A.3
Estimation results tables

Table A.3 – Estimated coefficients of the production function

lnq		S1	S2[a]	S3	S4[c]	S5	S6	S7	S8	S9[b]
constant	β_0	7.663**	10.86**	5.319**	9.753**	9.797	10.68**	7.626**	8.355	5.822**
		(21.67)[d]	(22.119)	(10.215)	(15.404)	(0.457)	(18.893)	(13.039)	(0.040)	(4.95)
lnempleo	β_1	0.458**	0.852**	0.982**	1.217**	1.214**	1.455**	2.048**	1.86	1.627**
		(4.717)	(5.164)	(6.565)	(9.65)	(6.391)	(7.253)	(9.77)	(0.058)	(3.69)
lnm	β_2	-0.248**	-0.639**	0.083	-0.632**	-0.407**	-0.780**	-0.464**	-0.338	-0.01
		(-3.764)	(-10.88)	(0.853)	(-5.386)	(-4.427)	(-7.383)	(-3.543)	(-1.411)	(-0.03)
lnelectr	β_3	0.332**	0.328**	0.218**	0.417**	0.609**	0.185**	0.154	0.131	-0.158
		(7.107)	(5.547)	(2.956)	(6.22)	(6.857)	(2.055)	(1.595)	(0.675)	(-0.91)
lemlel	β_4	0.01	0.01	-0.04**	-0.063**	0.02	0.016	0.011	0.045	-0.06**
		(1.094)	(0.78)	(-2.490)	(-4.883)	(0.931)	(0.699)	(0.572)	(0.953)	(-2.15)
lemlm	β_5	-0.111**	-0.141**	-0.092**	-0.101**	-0.140**	-0.162**	-0.191**	-0.181**	-0.17**
		(-14.21)	(-11.02)	(-5.014)	(-6.960)	(-7.31)	(-6.848)	(-7.127)	(-4.001)	(-2.71)
lmlel	β_6	-0.037**	-0.026**	-0.021**	-0.036**	-0.072**	-0.016	-0.012	-0.014	0.039*
		(-6.72)	(-4.003)	(-2.635)	(-5.735)	(-7.219)	(-1.619)	(-0.895)	(-0.616)	(1.84)
lem2d	β_7	0.379**	0.253**	0.159**	0.213**	0.146**	0.223**	0.189**	0.201**	0.302**
		(12.038)	(6.53)	(3.794)	(5.489)	(2.468)	(3.942)	(3.025)	(2.186)	(2.32)
lm2d	β_8	0.121**	0.006	0.085**	0.14**	0.154**	0.164**	0.145**	0.133**	0.088**
		(17.797)	(0.723)	(7.862)	(12.013)	(13.211)	(12.506)	(8.327)	(4.192)	(2.44)
lel2d	β_9	0.038**	0.154**	0.057**	0.064**	0.065**	0.003	0.009	-0.022	-0.003
		(6.459)	(21.762)	(5.749)	(21.895)	(5.007)	(0.215)	(0.675)	(-0.72)	(-0.22)
N		2946	1837	1066	1144	599	871	945	375	230

[a] MLE without local indicators
[b] OLS estimation without efficiency indicators
[c] Estimation of sector 4 with local indicators had to be done providing starting values for the iteration process, as the usual process of frontier 4.1 was providing a LL function higher for MLE than for OLS. Yet, we have provided exactly the same starting values used by the programme in the usual process, with the exception of the value of g, which was set equal to its value in the estimation without local indicators; we thus believe that the correction do not influence sensibly the results.
[d] Numbers in parenthesis are the respective t-ratio. Coefficients reported with ** indicate a 95% significance level, * 90% s.l.

Table A.4 – Input elasticities by OLS estimates per sector (complete sample)

Sector	L	K	M	TRS
S1	0.245	0.086	0.743	1.074
S2	0.347	0.084	0.658	1.089
S3	0.254	0.065	0.737	1.056
S4	0.339	0.045	0.681	1.065
S5	0.224	0.131	0.690	1.045
S6	0.399	0.057	0.599	1.055
S7	0.415	0.079	0.604	1.098
S8	0.514	0.021	0.600	1.135
S9	0.233	0.102	0.709	1.044

Notes: L is labour input, K capital input, M material inputs, and TRS total returns to scale.

Table A.5 – Input elasticities by OLS estimates per sector (reduced sample for municipal indicators)

Sector	L	K	M	TRS
S1	0.249	0.083	0.745	1.077
S2	0.347	0.084	0.658	1.089
S3	0.273	0.058	0.731	1.061
S4	0.342	0.046	0.679	1.067
S5	0.228	0.130	0.689	1.046
S6	0.400	0.056	0.599	1.055
S7	0.414	0.080	0.604	1.098
S8	0.510	0.027	0.597	1.134
S9	0.234	0.103	0.707	1.044

Notes: L is labour input, K capital input, M material inputs, and TRS total returns to scale.

Table A.6 – Input elasticities by MLE per sector (complete sample)

Sector	L	K	M	TRS
S1	0.484	0.082	0.715	1.281
S2	0.075	0.073	0.634	0.782
S3	0.078	0.076	0.714	0.868
S4	0.260	0.041	0.640	0.941
S5	0.076	0.117	0.659	0.852
S6	0.357	0.057	0.585	0.999
S7	0.418	0.089	0.572	1.078
S8	0.303	0.024	0.581	0.907
S9	-0.011	0.095	0.692	0.776

Notes: L is labour input, K capital input, M material inputs, and TRS total returns to scale.

Table A.7– Input elasticities by MLE per sector (reduced sample for municipal indicators)

Sector	L	K	M	TRS
S1	0.470	0.081	0.719	1.270
S2	0.120	0.072	0.633	0.825
S3	0.230	0.072	0.715	1.018
S4	0.363	0.048	0.627	1.039
S5	0.073	0.120	0.654	0.847
S6	0.334	0.053	0.591	0.978
S7	0.438	0.092	0.571	1.101
S8	0.583	0.026	0.559	1.168
S9	-0.025	0.101	0.706	0.783

Notes: L is labour input, K capital input, M material inputs, and TRS total returns to scale.

APPENDIX A.4
Descriptive statistics tables

Table A.8 – Percentage of firms in Ferraz taxonomy classes

Sector / Ferraz	S1	S2	S3	S4	S5	S6	S7	S8	S9
F1	0	16.28	49.92	20.67	15.46	0	4.95	0	100
F2	15	0	0	0	0	0	0	0	0
F3	85	83.72	50.08	69.64	84.54	96.38	3.26	100	0
F4	0	0	0	0	0	3.62	10.95	0	0
F5	0	0	0	0	0	0	16.95	0	0
F6	0	0	0	9.69	0	0	63.89	0	0

(Source: aouthor elaboration from ENIA database)

Table A.9 – Regional denomination and natural resources endowments

	Region	Forest[a]	Agriculture[b]	Coast[c]	Mine[d]
R1	Tarapacá	0.41	0.00	4.2	104555
R2	Antofagasta	0.00	0.00	5	400041
R3	Atacama	0.02	0.20	3.9	153342
R4	Coquimbo	1.35	17.98	3.2	48206
R5	Valparaíso	3.46	19.98	1.9	36135
R6	Del Libertador	5.13	26.96	1.2	27857
R7	Del Maule	11.47	33.18	1.8	7517
R8	Del Biobío	20.56	25.26	2.5	12271
R9	De La Araucanía	9.51	37.11	2	4218
R10	De Los Lagos	2.48	19.25	4.9	4983
R11	De Aysén	0.21	1.41	5.7	8965
R12	De Magallanes	0.00	6.61	7.8	133388
R13	Metropolitana de Santiago	0.82	21.76	0	34885

[a] Percentage of national forest surface in 1996 (Source: INFOR / INE)
[b] Percentage of national agricultural surface in 1997 (Source: ODEPA / INE)
[c] Coastal length in decimal scale in 1996 (Source: UNDP)
[d] Number of concessions for mine exploitation in 1997 (Source: INE)

Table A.10 – Percentage of firms per region per sector

Sector / Region	S1	S2	S3	S4	S5	S6	S7	S8	S9	Total
R1	2.97	1.31	0.90	2.85	4.93	2.72	2.95	5.31	2.17	2.90
R2	2.34	0	0.90	4.07	7.40	4.87	4.32	3.98	0	3.10
R3	1.22	0	0.33	0.78	3.45	1.70	1.89	1.33	0	1.19
R4	3.84	0.44	1.23	0.52	3.29	0.79	1.16	2.12	0	1.49
R5	12.19	5.72	4.85	6.92	9.05	4.08	4.63	5.57	3.91	6.32
R6	5.41	0.22	3.04	0.61	2.80	1.70	2.74	0.27	3.91	2.30
R7	6.53	0.98	8.63	1.04	1.64	0.79	1.79	2.39	3.04	2.98
R8	12.54	5.12	22.70	4.15	8.88	8.61	9.05	6.37	7.39	9.42
R9	2.16	0.76	6.91	0.61	2.63	1.36	1.47	2.12	0.87	2.10
R10	8.16	0.76	8.14	0.95	2.63	2.27	2.21	1.59	0.87	3.06
R11	0.50	0.11	1.15	0	0.16	0	0	1.06	0	0.33
R12	1.59	0.22	1.56	0.61	0.66	0.68	0.53	1.06	0	0.77
R13	40.54	84.38	39.64	76.90	52.47	70.44	67.26	66.84	77.83	64.03

(Source: aouthor elaboration from ENIA database)

Table A.11 – Percentage of firms per size per sector

Sector Size	S1	S2	S3	S4	S5	S6	S7	S8	S9
10-19	33.54	31.14	26.40	25.17	21.55	23.33	26.00	37.40	16.09
20-49	35.54	38.49	37.83	30.80	33.06	38.62	40.21	39.52	32.61
50-99	11.22	15.46	19.49	17.39	17.43	21.40	16.53	11.94	17.39
100-199	9.47	8.49	10.12	15.66	11.84	10.19	10.21	5.57	14.35
200-499	7.35	4.74	5.18	9.00	12.01	5.78	5.47	3.18	14.78
500-999	2.44	1.36	0.82	1.73	3.78	0.68	0.84	1.33	4.78
> 1000	0.44	0.33	0.16	0.26	0.33	0	0.74	1.06	0
Tot >100	19.7	14.92	16.28	26.65	27.96	16.65	17.26	11.14	33.91

(Source: aouthor elaboration from ENIA database)

Table A.12 - Correlation among size and foreign/public ownership

	formaj	pub	tamano
Formaj	1.0000		
Pub	-0.0162	1.0000	
Tamano	0.1786*	0.0818*	1.0000

Table A.13 – Summary descriptive statistics per sector

Variable Sector	K/L	Size > 100	Foreign	Public	Managers	Skilled	Males
S0	1.228				0.072	0.286	0.726
S1	1.302	19.7	3.970	0.090	0.061	0.264	0.722
S2	1.167	14.92	1.58	0.05	0.069	0.281	0.497
S3	1.273	16.28	2.47	0.25	0.056	0.197	0.904
S4	1.456	26.65	13.32	1.04	0.065	0.312	0.803
S5	1.420	27.96	4.11	4.28	0.051	0.310	0.910
S6	1.214	16.65	2.27	0.57	0.065	0.320	0.899
S7	1.242	17.26	4.74	4.74	0.070	0.348	0.897
S8	1.222	11.14	1.86	1.33	0.082	0.426	0.808
S9	1.389	33.91	7.83	0	0.064	0.347	0.823
Total	1.284	20.497	4.683	1.372	0.064	0.287	0.759

Notes: *K/L* is the ratio of capital of labour usage; *Size > 100* the % of firms with more than 100 employees; *Foreign* is the % of plants with majority of foreign ownership; *Public* the % of plants with public ownership; *Managers*, *Skilled* and *Males* the ratio of respectively managers, skilled and male workers on total labour force
(Source: aouthor elaboration from ENIA database)

Table A.14 – Ratio of managers per sector per centiles

Sector	Mean	N	p10	p25	p50	p75	p90	max	sd
S0	0.072	168	0.000	0.029	0.062	0.091	0.160	0.286	0.066
S1	0.061	3199	0.000	0.013	0.048	0.091	0.143	0.818	0.064
S2	0.069	1837	0.000	0.021	0.053	0.095	0.154	1.000	0.078
S3	0.056	1216	0.000	0.017	0.043	0.081	0.125	0.324	0.053
S4	0.065	1156	0.000	0.024	0.051	0.091	0.143	0.368	0.058
S5	0.051	608	0.000	0.014	0.034	0.072	0.105	0.950	0.066
S6	0.065	883	0.000	0.022	0.049	0.091	0.143	0.429	0.061
S7	0.070	950	0.000	0.027	0.054	0.098	0.150	0.813	0.065
S8	0.082	377	0.013	0.032	0.065	0.111	0.167	0.455	0.070
S9	0.064	230	0.013	0.024	0.048	0.086	0.133	0.385	0.059
Total	0.064	10624	0.000	0.019	0.049	0.091	0.143	1.000	0.065

Note: N = sample; p number = percentile; sd = standard deviation
(Source: aouthor elaboration from ENIA database)

Table A.15 - Ratio of managers per region per centiles

Region	mean	N	p10	p25	p50	p75	p90	max	sd
R1	0.060	272	0.000	0.011	0.048	0.091	0.143	0.316	0.058
R2	0.089	277	0.000	0.021	0.063	0.111	0.200	0.950	0.105
R3	0.046	111	0.000	0.000	0.031	0.071	0.105	0.308	0.060
R4	0.062	198	0.000	0.017	0.056	0.091	0.136	0.308	0.053
R5	0.066	807	0.000	0.018	0.053	0.095	0.143	0.800	0.066
R6	0.056	289	0.000	0.003	0.037	0.077	0.143	0.818	0.076
R7	0.057	394	0.000	0.020	0.049	0.077	0.118	0.556	0.055
R8	0.055	1085	0.000	0.016	0.043	0.083	0.125	0.480	0.052
R9	0.065	228	0.000	0.018	0.047	0.088	0.154	0.563	0.072
R10	0.043	450	0.000	0.012	0.029	0.062	0.100	0.400	0.046
R11	0.042	37	0.000	0.015	0.022	0.050	0.065	0.250	0.053
R12	0.054	100	0.003	0.020	0.044	0.077	0.114	0.200	0.046
R13	0.07	6376	0	0.02	0.05	0.09	0.14	1	0.07
Total	0.06	10624	0	0.02	0.05	0.09	0.14	1	0.07

Note: N = sample; p number = percentile; sd = standard deviation
(Source: aouthor elaboration from ENIA database)

Table A.16 – Ratio of skilled workers per sector per percentile

Sector	mean	N	p10	p25	p50	p75	p90	sd
S0	0.286	168	0.054	0.100	0.176	0.337	0.864	0.279
S1	0.264	3199	0.000	0.075	0.173	0.360	0.727	0.264
S2	0.281	1837	0.038	0.087	0.160	0.333	0.875	0.294
S3	0.197	1216	0.036	0.069	0.123	0.217	0.455	0.225
S4	0.312	1156	0.092	0.148	0.231	0.387	0.728	0.240
S5	0.310	608	0.063	0.114	0.200	0.389	0.898	0.285
S6	0.320	883	0.071	0.118	0.200	0.422	0.864	0.286
S7	0.348	950	0.074	0.129	0.222	0.500	0.909	0.305
S8	0.426	377	0.100	0.174	0.308	0.733	0.895	0.305
S9	0.347	230	0.092	0.150	0.257	0.455	0.815	0.263
Total	0.287	10624	0.048	0.097	0.184	0.364	0.825	0.276

Note: N = sample; p number = percentile; sd = standard deviation
(Source: aouthor elaboration from ENIA database)

Table A17 – Ratio of skilled workers per region per percentile

Region	mean	N	p10	p25	p50	p75	p90	sd
R1	0.331	272	0.059	0.104	0.243	0.456	0.875	0.289
R2	0.362	277	0.065	0.143	0.250	0.571	0.880	0.294
R3	0.477	111	0.033	0.106	0.310	0.923	1.000	0.388
R4	0.162	198	0.000	0.042	0.114	0.200	0.333	0.196
R5	0.294	807	0.045	0.100	0.186	0.375	0.837	0.284
R6	0.356	289	0.024	0.072	0.231	0.643	1.000	0.346
R7	0.243	394	0.042	0.078	0.149	0.308	0.667	0.254
R8	0.239	1085	0.043	0.079	0.150	0.278	0.684	0.249
R9	0.206	228	0.023	0.067	0.110	0.230	0.551	0.236
R10	0.250	450	0.042	0.079	0.142	0.316	0.709	0.266
R11	0.261	37	0.045	0.080	0.110	0.251	0.938	0.311
R12	0.301	100	0.048	0.092	0.184	0.396	0.941	0.299
R13	0.3	6376	0.05	0.11	0.19	0.38	0.83	0.27
Total	0.29	10624	0.05	0.1	0.18	0.36	0.83	0.28

Note: N = sample; p number = percentile; sd = standard deviation
(Source: aouthor elaboration from ENIA database)

Table A.18 – Ratio of male workers per sector per percentile

Sector	mean	N	p5	p10	p25	p50	p75	p90	p95
S0	0.726	168	0.308	0.386	0.542	0.788	0.922	0.964	1.000
S1	0.722	3199	0.333	0.448	0.600	0.750	0.887	0.957	0.982
S2	0.497	1837	0.111	0.158	0.268	0.471	0.714	0.903	0.954
S3	0.904	1216	0.692	0.784	0.879	0.934	0.977	1.000	1.000
S4	0.803	1156	0.393	0.495	0.715	0.875	0.938	0.980	1.000
S5	0.910	608	0.667	0.800	0.900	0.951	0.982	1.000	1.000
S6	0.899	883	0.667	0.778	0.875	0.931	0.968	1.000	1.000
S7	0.897	950	0.714	0.800	0.870	0.924	0.962	1.000	1.000
S8	0.808	377	0.576	0.625	0.740	0.818	0.905	0.956	1.000
S9	0.823	230	0.462	0.600	0.745	0.865	0.943	0.973	0.990
Total	0.759	10624	0.250	0.381	0.636	0.846	0.940	0.983	1.000

Note: N = sample; p number = percentile; sd = standard deviation
(Source: aouthor elaboration from ENIA database)

Table A19 – Efficiency per sector

sector	Mean	N	p10	p25	p50	p75	p90	max	min	sd
S1	0.822	2946	0.447	0.825	0.923	0.943	0.952	1.000	0.062	0.211
S2[a]	0.642	1837	0.417	0.494	0.626	0.795	0.905	0.968	0.214	0.178
S3	0.868	1066	0.785	0.815	0.866	0.908	0.978	1.000	0.692	0.068
S4	0.808	1144	0.671	0.714	0.799	0.893	0.978	1.000	0.557	0.108
S5	0.122	599	0.076	0.090	0.110	0.141	0.183	0.508	0.040	0.050
S6	0.865	871	0.741	0.798	0.888	0.944	0.967	0.990	0.540	0.091
S7	0.823	945	0.709	0.781	0.838	0.883	0.919	0.975	0.401	0.089
S8	0.276	375	0.224	0.246	0.272	0.306	0.330	0.488	0.158	0.042

[a] Value computed with no local factors and complete sample
Note: N = sample; p number = percentile; sd = standard deviation

Table A.20 – Efficiency sector 1

Region	Mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.809	95	0.433	0.757	0.921	0.942	0.953	0.966	0.139	0.210
R2	0.884	73	0.732	0.892	0.938	0.952	0.957	0.967	0.315	0.131
R3	0.840	37	0.486	0.864	0.913	0.943	0.953	0.964	0.288	0.177
R4	0.769	123	0.303	0.632	0.925	0.945	0.953	0.974	0.119	0.270
R5	0.865	389	0.744	0.889	0.927	0.944	0.952	0.970	0.089	0.175
R6	0.818	131	0.405	0.820	0.926	0.945	0.952	1.000	0.131	0.219
R7	0.830	180	0.506	0.844	0.917	0.943	0.953	0.968	0.135	0.198
R8	0.788	361	0.396	0.709	0.908	0.938	0.948	0.968	0.062	0.231
R9	0.807	62	0.397	0.745	0.914	0.937	0.949	0.960	0.273	0.198
R10	0.673	148	0.274	0.449	0.731	0.922	0.945	0.962	0.102	0.262
R11	0.582	15	0.312	0.341	0.580	0.815	0.843	0.897	0.193	0.242
R12	0.781	51	0.589	0.656	0.833	0.911	0.930	0.962	0.310	0.155
R13	0.843	1281	0.514	0.867	0.929	0.944	0.952	0.978	0.097	0.198
Total	0.822	2946	0.447	0.825	0.923	0.943	0.952	1.000	0.062	0.211

Note: N = sample; p number = percentile; sd = standard deviation

Table A.21 – Efficiency sector 2[a]

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.609	24	0.333	0.423	0.575	0.776	0.939	0.953	0.325	0.222
R4	0.605	8	0.425	0.437	0.594	0.754	0.848	0.848	0.425	0.178
R5	0.569	105	0.393	0.426	0.547	0.664	0.808	0.963	0.324	0.158
R6	0.509	4	0.320	0.346	0.517	0.671	0.681	0.681	0.320	0.189
R7	0.688	18	0.436	0.478	0.694	0.890	0.940	0.943	0.314	0.217
R8	0.567	94	0.391	0.431	0.502	0.696	0.894	0.956	0.308	0.182
R9	0.492	14	0.339	0.452	0.487	0.530	0.665	0.689	0.309	0.103
R10	0.556	14	0.454	0.492	0.536	0.608	0.611	0.854	0.444	0.102
R11	0.464	2	0.455	0.455	0.464	0.472	0.472	0.472	0.455	0.012
R12	0.549	4	0.338	0.368	0.537	0.731	0.785	0.785	0.338	0.216
R13	0.655	1550	0.427	0.510	0.645	0.806	0.907	0.968	0.214	0.176
Total	0.642	1837	0.417	0.494	0.626	0.795	0.905	0.968	0.214	0.178

[a] Value computed with no local factors and complete sample

Note: N = sample; p number = percentile; sd = standard deviation

Table A.22 – Efficiency sector 3

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.899	11	0.872	0.880	0.903	0.915	0.920	0.921	0.871	0.018
R2	0.952	11	0.922	0.928	0.948	0.971	0.978	0.989	0.910	0.025
R3	0.840	4	0.807	0.817	0.844	0.862	0.863	0.863	0.807	0.027
R4	0.853	15	0.829	0.831	0.842	0.855	0.906	0.937	0.827	0.031
R5	0.882	59	0.807	0.846	0.883	0.912	0.940	0.996	0.793	0.051
R6	0.806	30	0.775	0.779	0.799	0.821	0.844	0.899	0.768	0.032
R7	0.803	91	0.752	0.771	0.794	0.822	0.863	0.994	0.739	0.050
R8	0.826	208	0.761	0.794	0.813	0.854	0.895	0.996	0.692	0.059
R9	0.823	74	0.738	0.774	0.824	0.853	0.914	1.000	0.696	0.070
R10	0.853	52	0.780	0.792	0.819	0.906	0.994	0.996	0.763	0.082
R11	0.871	14	0.834	0.858	0.869	0.879	0.926	0.926	0.801	0.034
R12	0.945	17	0.908	0.922	0.939	0.962	0.996	1.000	0.905	0.030
R13	0.904	480	0.841	0.868	0.892	0.937	0.995	1.000	0.777	0.051
Total	0.868	1066	0.785	0.815	0.866	0.908	0.978	1.000	0.692	0.068

Note: N = sample; p number = percentile; sd = standard deviation

Table A.23 – Efficiency sector 4

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.805	33	0.695	0.731	0.797	0.836	0.986	1.000	0.670	0.096
R2	0.904	43	0.767	0.846	0.920	0.990	0.994	0.996	0.726	0.086
R3	0.922	9	0.733	0.907	0.969	0.994	0.995	0.995	0.733	0.105
R4	0.733	6	0.667	0.669	0.704	0.822	0.833	0.833	0.667	0.075
R5	0.840	79	0.685	0.757	0.832	0.936	0.993	0.996	0.648	0.106
R6	0.939	7	0.809	0.880	0.979	0.994	0.994	0.994	0.809	0.071
R7	0.770	8	0.626	0.691	0.758	0.827	0.978	0.978	0.626	0.114
R8	0.786	48	0.634	0.658	0.748	0.945	0.987	0.996	0.613	0.138
R9	0.617	7	0.557	0.570	0.584	0.660	0.710	0.710	0.557	0.059
R10	0.667	8	0.594	0.625	0.681	0.691	0.747	0.747	0.594	0.050
R12	0.879	7	0.718	0.722	0.898	0.996	0.996	0.996	0.718	0.126
R13	0.803	889	0.675	0.712	0.793	0.880	0.969	1.000	0.621	0.103
Total	0.808	1144	0.671	0.714	0.799	0.893	0.978	1.000	0.557	0.108

Note: N = sample; p number = percentile; sd = standard deviation

Table A.24 – Efficiency sector 5

Region	Mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.111	30	0.079	0.090	0.108	0.118	0.170	0.224	0.049	0.038
R2	0.143	45	0.074	0.101	0.138	0.182	0.240	0.255	0.040	0.059
R3	0.184	21	0.082	0.101	0.184	0.213	0.295	0.508	0.069	0.110
R4	0.083	20	0.047	0.079	0.087	0.096	0.101	0.105	0.040	0.019
R5	0.115	55	0.071	0.084	0.101	0.139	0.168	0.265	0.054	0.046
R6	0.175	15	0.085	0.108	0.119	0.284	0.347	0.358	0.077	0.098
R7	0.079	9	0.067	0.072	0.076	0.088	0.092	0.092	0.067	0.009
R8	0.111	54	0.077	0.087	0.101	0.121	0.146	0.236	0.057	0.038
R9	0.093	16	0.077	0.080	0.092	0.102	0.118	0.131	0.058	0.018
R10	0.088	13	0.076	0.084	0.090	0.093	0.101	0.110	0.064	0.012
R12	0.080	4	0.046	0.057	0.083	0.102	0.107	0.107	0.046	0.028
R13	0.123	317	0.081	0.096	0.117	0.144	0.168	0.281	0.056	0.038
Total	0.122	599	0.076	0.090	0.110	0.141	0.183	0.508	0.040	0.050

Note: N = sample; p number = percentile; sd = standard deviation

Table A.25 – Efficiency sector 6

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.964	24	0.936	0.948	0.966	0.983	0.984	0.990	0.921	0.020
R2	0.949	43	0.948	0.965	0.971	0.977	0.986	0.988	0.589	0.081
R3	0.839	15	0.549	0.795	0.873	0.947	0.957	0.960	0.540	0.139
R4	0.745	7	0.643	0.738	0.763	0.772	0.789	0.789	0.643	0.048
R5	0.817	36	0.706	0.738	0.816	0.901	0.927	0.957	0.659	0.089
R6	0.702	10	0.643	0.657	0.675	0.736	0.823	0.853	0.629	0.071
R7	0.733	7	0.621	0.639	0.733	0.778	0.883	0.883	0.621	0.088
R8	0.815	72	0.719	0.763	0.815	0.879	0.933	0.978	0.629	0.082
R9	0.668	12	0.603	0.608	0.669	0.709	0.765	0.766	0.581	0.062
R10	0.742	19	0.673	0.705	0.732	0.790	0.819	0.872	0.608	0.062
R12	0.930	6	0.891	0.905	0.932	0.952	0.966	0.966	0.891	0.028
R13	0.878	620	0.770	0.820	0.897	0.941	0.963	0.981	0.591	0.075
Total	0.865	871	0.741	0.798	0.888	0.944	0.967	0.990	0.540	0.091

Note: N = sample; p number = percentile; sd = standard deviation

Table A.26 – Efficiency sector 7

Region	Mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.931	28	0.898	0.922	0.935	0.943	0.956	0.971	0.869	0.023
R2	0.874	41	0.776	0.881	0.907	0.918	0.928	0.935	0.597	0.087
R3	0.726	18	0.574	0.649	0.743	0.830	0.907	0.924	0.427	0.126
R4	0.757	11	0.695	0.710	0.748	0.781	0.841	0.891	0.635	0.069
R5	0.846	44	0.775	0.809	0.860	0.895	0.921	0.964	0.582	0.077
R6	0.904	24	0.860	0.884	0.903	0.920	0.950	0.970	0.851	0.031
R7	0.642	17	0.563	0.603	0.629	0.677	0.778	0.779	0.401	0.091
R8	0.768	83	0.673	0.729	0.771	0.813	0.861	0.959	0.508	0.081
R9	0.631	14	0.551	0.589	0.611	0.676	0.719	0.737	0.548	0.060
R10	0.682	21	0.518	0.630	0.678	0.760	0.812	0.854	0.468	0.106
R12	0.736	5	0.598	0.732	0.749	0.766	0.835	0.835	0.598	0.087
R13	0.836	639	0.752	0.801	0.843	0.879	0.910	0.975	0.436	0.068
Total	0.823	945	0.709	0.781	0.838	0.883	0.919	0.975	0.401	0.089

Note: N = sample; p number = percentile; sd = standard deviation

Table A.27 – Efficiency sector 8

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.242	20	0.211	0.219	0.226	0.258	0.301	0.330	0.208	0.035
R2	0.309	15	0.261	0.273	0.299	0.335	0.386	0.408	0.257	0.045
R3	0.271	5	0.213	0.245	0.279	0.305	0.313	0.313	0.213	0.042
R4	0.232	8	0.213	0.218	0.224	0.250	0.258	0.258	0.213	0.018
R5	0.291	21	0.243	0.273	0.298	0.317	0.327	0.343	0.225	0.034
R6	0.264	1	0.264	0.264	0.264	0.264	0.264	0.264	0.264	.
R7	0.272	9	0.223	0.241	0.259	0.301	0.345	0.345	0.223	0.044
R8	0.263	24	0.239	0.244	0.258	0.280	0.300	0.326	0.209	0.027
R9	0.215	8	0.158	0.193	0.215	0.240	0.267	0.267	0.158	0.036
R10	0.237	4	0.221	0.225	0.238	0.250	0.252	0.252	0.221	0.015
R11	0.250	4	0.236	0.236	0.245	0.264	0.273	0.273	0.236	0.018
R12	0.330	4	0.218	0.236	0.307	0.424	0.488	0.488	0.218	0.121
R13	0.281	252	0.232	0.253	0.278	0.308	0.333	0.397	0.203	0.039
Total	0.276	375	0.224	0.246	0.272	0.306	0.330	0.488	0.158	0.042

Note: N = sample; p number = percentile; sd = standard deviation

Table A.28 – Efficiency sector 9

Region	mean	N	p10	p25	p50	p75	p90	max	min	sd
R1	0.344	5	0.159	0.216	0.293	0.373	0.678	0.678	0.159	0.203
R5	0.299	9	0.151	0.280	0.288	0.339	0.427	0.427	0.151	0.085
R6	0.288	9	0.232	0.259	0.291	0.322	0.337	0.337	0.232	0.037
R7	0.314	5	0.239	0.264	0.284	0.388	0.394	0.394	0.239	0.072
R8	0.386	17	0.251	0.309	0.383	0.445	0.539	0.657	0.155	0.122
R9	0.444	2	0.432	0.432	0.444	0.455	0.455	0.455	0.432	0.016
R10	0.312	2	0.311	0.311	0.312	0.313	0.313	0.313	0.311	0.001
R13	0.282	179	0.158	0.196	0.260	0.339	0.439	0.994	0.080	0.125
Total	0.295	228	0.159	0.213	0.274	0.350	0.442	0.994	0.080	0.124

Note: N = sample; p number = percentile; sd = standard deviation

Table A.29 – Mean efficiency per sector per region

Sector / Region	S1	S2[a]	S3	S4	S5	S6	S7	S8	mean
R1	0.809	0.609	0.899	0.805	0.111	0.964	0.931	0.242	0.671
R2	0.884	--	0.952	0.904	0.143	0.949	0.874	0.309	0.716
R3	0.840	--	0.840	0.922	0.184	0.839	0.726	0.271	0.660
R4	0.769	0.605	0.853	0.733	0.083	0.745	0.757	0.232	0.597
R5	0.865	0.569	0.882	0.840	0.115	0.817	0.846	0.291	0.653
R6	0.818	0.509	0.806	0.939	0.175	0.702	0.904	0.264	0.640
R7	0.830	0.688	0.803	0.770	0.079	0.733	0.642	0.272	0.602
R8	0.788	0.567	0.826	0.786	0.111	0.815	0.768	0.263	0.616
R9	0.807	0.492	0.823	0.617	0.093	0.668	0.631	0.215	0.543
R10	0.673	0.556	0.853	0.667	0.088	0.742	0.682	0.237	0.562
R11	0.582	0.464	0.871	--	--	--	--	0.250	0.542
R12	0.781	0.549	0.945	0.879	0.080	0.930	0.736	0.330	0.654
R13	0.843	0.655	0.904	0.803	0.123	0.878	0.836	0.281	0.665
Total	0.822	0.642	0.868	0.808	0.122	0.865	0.823	0.276	0.653

[a] Computed with no local indicators

Table A.30 - Correlation matrix among form efficiency variables S1[1]

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.007	1.000													
impdm	0.170	-0.002	1.000												
lmale	0.079	-0.006	0.108	1.000											
lmanag	-0.081	-0.017	-0.052	-0.056	1.000										
lskill	0.063	-0.004	0.049	0.120	0.071	1.000									
ci	0.056	0.006	-0.039	-0.020	-0.057	-0.033	1.000								
lnempleo	0.249	0.045	0.230	0.046	-0.439	-0.056	0.116	1.000							
lworkf	-0.077	-0.045	-0.002	-0.060	0.030	0.014	-0.159	-0.045	1.000						
runemp	-0.015	-0.032	-0.013	-0.005	-0.035	-0.042	0.001	-0.020	0.007	1.000					
lschool	-0.078	-0.019	-0.005	-0.100	0.084	0.034	-0.345	-0.085	0.602	-0.291	1.000				
lwageav	-0.066	0.024	-0.021	-0.078	0.087	0.029	-0.328	-0.069	0.372	-0.463	0.875	1.000			
lpubi	-0.041	-0.030	0.042	-0.002	-0.005	0.033	-0.672	-0.065	0.212	0.001	0.326	0.317	1.000		
lkmpc	-0.067	-0.010	0.076	-0.050	0.022	0.045	-0.625	-0.114	0.178	-0.132	0.374	0.343	0.809	1.000	
ltecfund	-0.022	-0.015	0.050	-0.014	-0.008	0.025	-0.694	-0.046	0.234	-0.031	0.362	0.364	0.961	0.793	1.000

Table A.31 - Correlation matrix among form efficiency variables S2

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.003	1.000													
impdm	0.037	-0.012	1.000												
lmale	0.005	0.011	0.197	1.000											
lmanag	-0.006	0.017	-0.108	0.005	1.000										
lskill	-0.012	-0.022	0.021	-0.018	-0.010	1.000									
ci	-0.009	0.010	0.075	0.034	0.022	0.033	1.000								
lnempleo	0.073	-0.020	0.361	0.140	-0.429	-0.082	0.040	1.000							
lworkf	-0.018	-0.029	-0.024	-0.174	-0.023	0.050	0.120	0.025	1.000						
runemp	0.015	-0.024	-0.028	0.060	-0.049	-0.040	-0.078	0.041	0.074	1.000					
lschool	-0.061	0.014	0.001	-0.121	0.027	0.056	0.187	-0.041	0.403	-0.597	1.000				
lwageav	-0.060	0.009	0.010	-0.106	0.033	0.054	0.225	-0.051	0.264	-0.649	0.952	1.000			
lpubi	-0.087	0.010	0.025	0.053	0.018	0.009	0.923	0.021	0.117	-0.030	0.197	0.230	1.000		
lkmpc	-0.025	0.009	0.062	0.006	0.024	0.054	0.911	0.021	0.042	-0.049	0.124	0.153	0.847	1.000	
ltecfund	-0.062	0.010	0.029	0.056	0.010	0.009	0.933	0.022	0.120	-0.045	0.202	0.239	0.988	0.836	1.000

Table A.32 - Correlation matrix among form efficiency variables S3

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	0.138	1.000													
impdm	-0.021	-0.012	1.000												
lmale	-0.059	0.025	-0.078	1.000											
lmanag	-0.064	-0.046	-0.086	-0.144	1.000										
lskill	0.065	0.060	0.007	-0.172	0.025	1.000									
ci	0.084	0.016	-0.060	0.075	-0.142	-0.137	1.000								
lnempleo	0.151	0.060	0.149	0.054	-0.503	-0.058	0.195	1.000							
lworkf	-0.064	0.035	0.021	-0.127	0.086	0.006	-0.210	-0.063	1.000						
runemp	0.023	0.001	-0.058	0.073	-0.021	0.035	0.043	0.053	-0.180	1.000					
lschool	-0.086	0.016	0.047	-0.120	0.069	0.102	-0.295	-0.093	0.690	-0.437	1.000				
lwageav	-0.041	0.010	0.021	-0.070	0.022	0.062	-0.217	-0.072	0.414	-0.522	0.822	1.000			
lpubi	-0.047	-0.033	0.097	-0.082	0.022	0.095	-0.531	-0.043	0.230	-0.023	0.352	0.246	1.000		
lkmpc	-0.085	-0.038	0.098	-0.088	0.101	0.125	-0.847	-0.147	0.232	-0.095	0.366	0.275	0.862	1.000	
ltecfund	-0.034	-0.043	0.108	-0.084	0.043	0.102	-0.567	-0.053	0.260	-0.061	0.395	0.292	0.964	0.846	1.000

Table A.33 - Correlation matrix among form efficiency variables S4

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.040	1.000													
impdm	0.272	-0.069	1.000												
lmale	0.043	0.070	0.048	1.000											
lmanag	-0.078	0.014	-0.113	-0.071	1.000										
lskill	0.300	0.184	0.071	0.029	-0.013	1.000									
ci	0.011	-0.125	0.135	-0.080	-0.002	-0.135	1.000								
lnempleo	0.207	0.008	0.290	-0.029	-0.420	0.045	0.097	1.000							
lworkf	-0.045	-0.060	0.041	-0.098	0.050	-0.036	0.041	0.082	1.000						
runemp	-0.011	-0.039	0.064	0.044	-0.022	-0.027	-0.100	0.109	0.011	1.000					
lschool	-0.062	-0.021	0.006	-0.184	0.139	-0.038	0.090	-0.067	0.442	-0.424	1.000				
lwageav	-0.043	0.004	0.003	-0.171	0.107	0.016	0.127	-0.073	0.270	-0.526	0.917	1.000			
lpubi	-0.083	-0.176	0.002	-0.242	0.087	-0.177	0.399	0.061	0.068	0.217	0.105	0.081	1.000		
lkmpc	-0.044	-0.149	0.075	-0.200	0.028	-0.171	0.741	0.065	-0.007	0.082	0.084	0.091	0.836	1.000	
ltecfund	-0.074	-0.207	0.009	-0.243	0.092	-0.184	0.460	0.059	0.085	0.189	0.120	0.106	0.982	0.843	1.000

Table A.34 - Correlation matrix among form efficiency variables S5

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.053	1.000													
impdm	0.062	-0.087	1.000												
lmale	0.065	0.129	-0.054	1.000											
lmanag	-0.077	0.241	-0.057	-0.136	1.000										
lskill	0.172	0.142	-0.021	0.116	-0.154	1.000									
ci	0.076	0.335	-0.095	0.122	0.044	0.243	1.000								
lnempleo	0.261	0.170	0.185	0.185	-0.268	0.198	0.162	1.000							
lworkf	-0.174	-0.185	0.061	-0.001	0.085	-0.057	-0.092	-0.123	1.000						
runemp	-0.069	-0.186	0.172	-0.067	-0.153	-0.108	-0.205	0.087	-0.098	1.000					
lschool	-0.099	-0.063	-0.031	-0.028	0.120	0.046	0.082	-0.108	0.545	-0.313	1.000				
lwageav	-0.038	0.047	-0.080	0.041	0.114	0.117	0.166	-0.056	0.376	-0.529	0.846	1.000			
lpubi	-0.030	-0.279	0.208	-0.145	-0.006	-0.170	-0.623	-0.009	0.097	0.244	-0.060	-0.072	1.000		
lkmpc	0.063	-0.132	0.189	-0.115	0.041	-0.089	-0.309	0.040	0.061	0.036	-0.010	0.051	0.795	1.000	
ltecfund	-0.023	-0.276	0.218	-0.126	0.028	-0.179	-0.559	0.006	0.118	0.200	-0.044	-0.036	0.976	0.813	1.000

Table A.35 - Correlation matrix among form efficiency variables S6

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.012	1.000													
impdm	0.283	-0.030	1.000												
lmale	-0.008	0.062	-0.117	1.000											
lmanag	-0.064	0.149	-0.109	-0.130	1.000										
lskill	0.024	0.042	0.060	0.013	0.031	1.000									
ci	-0.013	0.116	0.082	0.028	-0.020	0.084	1.000								
lnempleo	0.129	0.065	0.277	0.179	-0.447	-0.029	0.080	1.000							
lworkf	0.026	-0.101	0.047	-0.044	0.074	0.014	-0.010	-0.041	1.000						
runemp	0.009	-0.124	0.054	-0.004	-0.126	-0.076	-0.126	0.155	-0.215	1.000					
lschool	-0.045	-0.034	-0.021	-0.075	0.085	0.038	0.120	-0.163	0.377	-0.555	1.000				
lwageav	-0.055	-0.001	-0.055	-0.058	0.068	0.044	0.158	-0.178	0.236	-0.617	0.916	1.000			
lpubi	0.039	-0.181	0.143	-0.124	-0.007	-0.065	0.036	-0.006	-0.063	0.084	0.129	0.118	1.000		
lkmpc	0.012	-0.097	0.174	-0.142	0.025	-0.017	0.307	-0.041	-0.012	-0.105	0.191	0.205	0.822	1.000	
ltecfund	0.029	-0.167	0.144	-0.122	-0.004	-0.069	0.131	-0.002	-0.050	0.038	0.145	0.151	0.981	0.840	1.000

Table A.36 - Correlation matrix among form efficiency variables S7

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.050	1.000													
impdm	0.322	-0.014	1.000												
lmale	-0.055	0.146	-0.139	1.000											
lmanag	-0.066	-0.160	-0.125	-0.139	1.000										
lskill	0.116	0.265	0.046	0.032	-0.007	1.000									
ci	0.040	0.065	0.075	-0.011	0.065	0.122	1.000								
lnempleo	0.198	0.194	0.364	0.071	-0.452	0.025	0.091	1.000							
lworkf	-0.040	-0.210	0.022	-0.126	0.145	-0.068	0.053	-0.020	1.000						
runemp	-0.034	-0.164	0.048	-0.037	-0.020	-0.008	-0.042	0.048	0.090	1.000					
lschool	0.039	-0.054	0.034	-0.113	0.121	-0.027	0.146	-0.055	0.460	-0.383	1.000				
lwageav	0.061	0.028	0.008	-0.101	0.097	0.021	0.143	-0.068	0.238	-0.526	0.894	1.000			
lpubi	0.055	-0.352	0.078	-0.158	0.126	-0.032	0.166	-0.006	0.087	0.196	0.141	0.078	1.000		
lkmpc	0.075	-0.242	0.114	-0.131	0.159	0.016	0.435	0.002	0.053	0.032	0.188	0.145	0.827	1.000	
ltecfund	0.050	-0.394	0.081	-0.156	0.143	-0.064	0.187	-0.023	0.125	0.164	0.170	0.110	0.977	0.839	1.000

Table A.37 - Correlation matrix among form efficiency variables S8

	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.015	1.000													
impdm	0.365	0.063	1.000												
lmale	0.055	-0.030	0.012	1.000											
lmanag	-0.054	-0.077	-0.135	-0.125	1.000										
lskill	-0.019	-0.034	-0.019	-0.174	-0.005	1.000									
ci	0.078	0.004	0.136	0.147	-0.068	-0.074	1.000								
lnempleo	0.204	0.160	0.431	0.073	-0.438	0.000	0.173	1.000							
lworkf	-0.020	0.045	-0.037	0.145	0.072	-0.019	0.002	0.000	1.000						
runemp	0.107	0.075	0.057	0.148	-0.060	-0.091	-0.149	0.018	0.059	1.000					
lschool	-0.078	0.009	0.015	0.029	-0.040	0.043	0.306	0.130	0.360	-0.536	1.000				
lwageav	-0.080	-0.009	0.025	-0.025	-0.024	0.090	0.250	0.132	0.145	-0.644	0.921	1.000			
lpubi	0.085	0.047	0.145	0.226	-0.108	-0.138	0.746	0.160	0.091	0.030	0.350	0.273	1.000		
lkmpc	0.080	0.017	0.149	0.218	-0.058	-0.045	0.749	0.149	0.149	0.032	0.340	0.246	0.838	1.000	
ltecfund	0.087	0.047	0.149	0.228	-0.098	-0.128	0.755	0.155	0.078	-0.035	0.365	0.309	0.982	0.852	1.000

Table A.38 - Correlation matrix among form efficiency variables S9

	extranje	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000													
impdm	0.338	1.000												
lmale	-0.037	-0.077	1.000											
lmanag	-0.091	-0.217	-0.255	1.000										
lskill	0.023	0.059	0.146	0.045	1.000									
ci	0.048	0.003	0.177	-0.079	0.041	1.000								
lnempleo	0.130	0.279	0.379	-0.466	0.155	0.207	1.000							
lworkf	-0.131	-0.165	-0.213	0.065	-0.073	-0.219	-0.328	1.000						
runemp	-0.045	-0.095	0.213	0.075	0.001	0.143	0.328	-0.209	1.000					
lschool	-0.046	-0.068	-0.341	0.106	0.027	-0.203	-0.440	0.584	-0.581	1.000				
lwageav	-0.015	-0.037	-0.323	0.097	0.039	-0.054	-0.362	0.412	-0.574	0.919	1.000			
lpubi	-0.155	-0.193	-0.015	0.084	-0.018	0.078	-0.285	0.318	-0.309	0.368	0.353	1.000		
lkmpc	-0.124	-0.073	-0.147	0.077	-0.098	-0.254	-0.390	0.371	-0.473	0.420	0.359	0.860	1.000	
Ltecfund	-0.167	-0.217	-0.036	0.090	-0.010	0.016	-0.280	0.354	-0.293	0.398	0.370	0.985	0.837	1.000

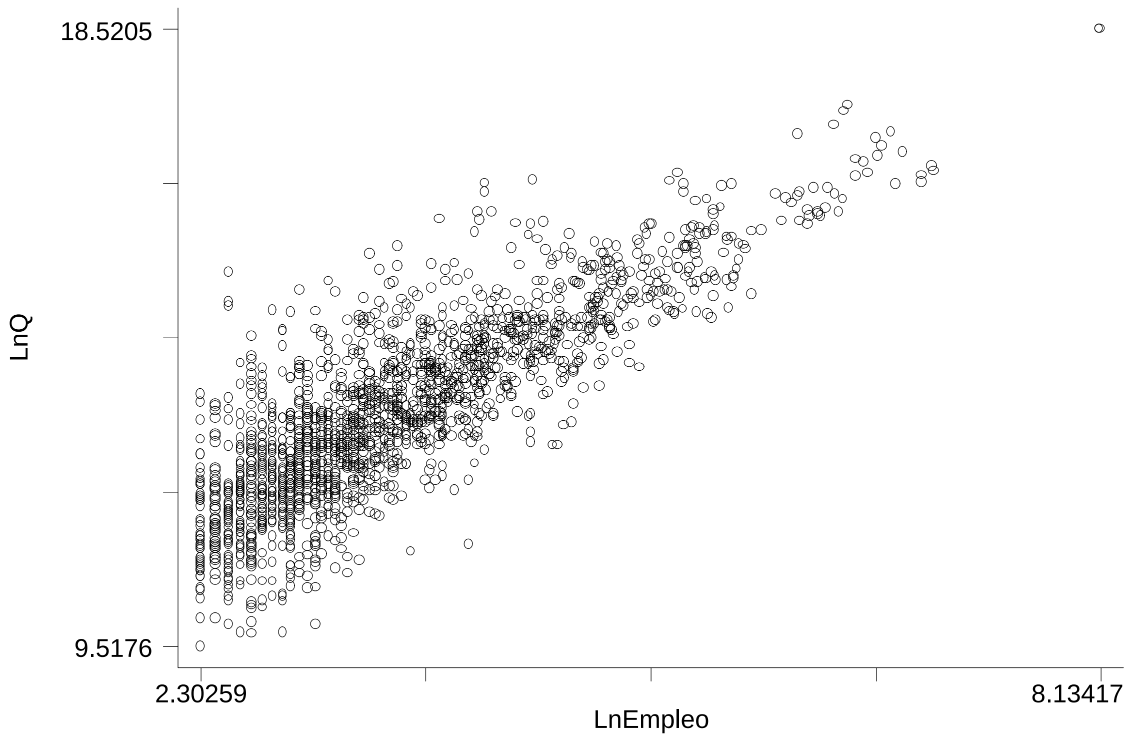
Table A.39 - Correlation matrix among form efficiency variables: entire sample[1]

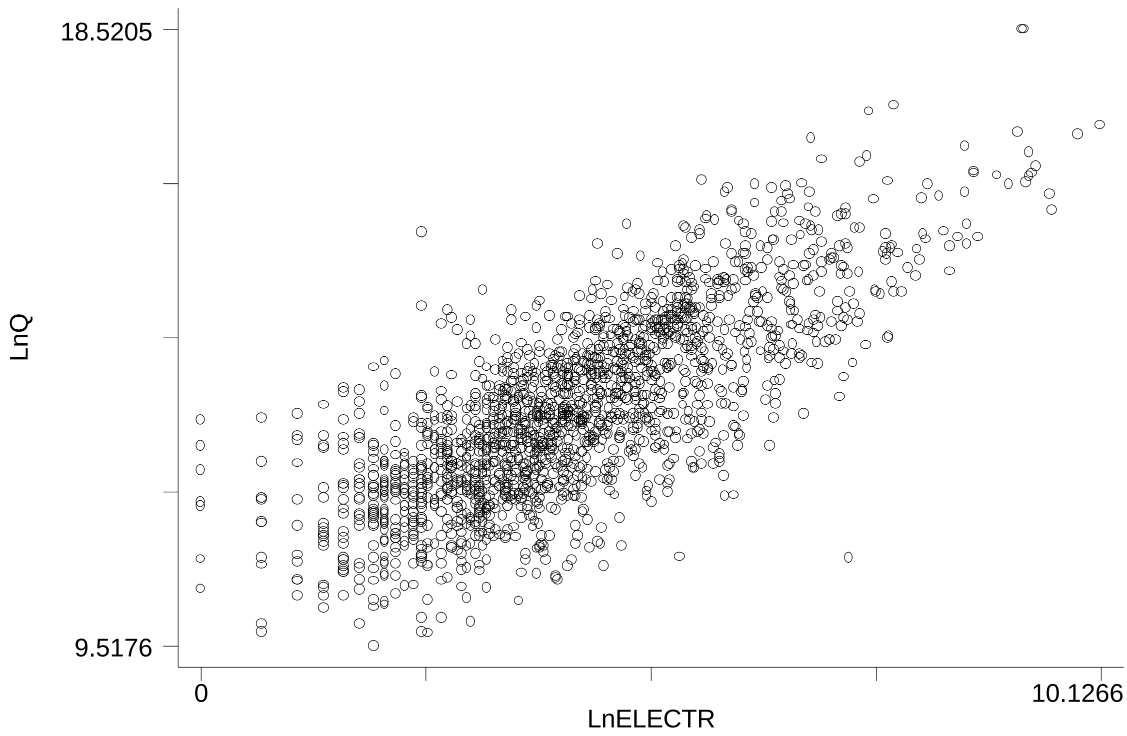
	extranje	pub	impdm	lmale	lmanag	lskill	ci	lnempleo	lworkf	runemp	lschool	lwageav	lpubi	lkmpc	ltecfund
extranje	1.000														
pub	-0.016	1.000													
impdm	0.225	-0.014	1.000												
lmale	0.045	0.081	0.032	1.000											
lmanag	-0.059	0.000	-0.083	-0.063	1.000										
lskill	0.098	0.109	0.053	0.039	0.021	1.000									
ci	0.033	0.076	0.006	0.004	-0.038	-0.013	1.000								
Lnempleo	0.197	0.089	0.277	0.100	-0.425	-0.011	0.116	1.000							
lworkf	-0.069	-0.080	0.026	-0.122	0.059	0.012	-0.096	-0.043	1.000						
runemp	-0.009	-0.066	0.007	0.041	-0.049	-0.047	-0.029	0.047	-0.038	1.000					
lschool	-0.056	-0.022	0.046	-0.167	0.087	0.054	-0.118	-0.085	0.547	-0.398	1.000				
Lwageav	-0.042	0.006	0.028	-0.144	0.077	0.057	-0.070	-0.077	0.340	-0.520	0.893	1.000			
lpubi	-0.023	-0.141	0.125	-0.116	0.034	-0.001	-0.259	-0.012	0.179	0.032	0.284	0.250	1.000		
lkmpc	-0.008	-0.076	0.161	-0.128	0.057	0.047	-0.286	-0.039	0.160	-0.092	0.314	0.274	0.835	1.000	
ltecfund	-0.013	-0.145	0.133	-0.113	0.040	-0.002	-0.261	-0.008	0.202	-0.004	0.314	0.286	0.974	0.835	1.000

[1] To analysed the correlation we have used continuous variables, in the place of dummies, when the information was available. Hence, EXTRANJE is the percentage of the plant owned by foreigners and IMPDM is the ratio of input imported with respect to the nationally acquired

APPENDIX A.5
Figures

Figure A.1 – Plots sector S1 (reduced sample): Lnempleo, Lnm, Lnelectr





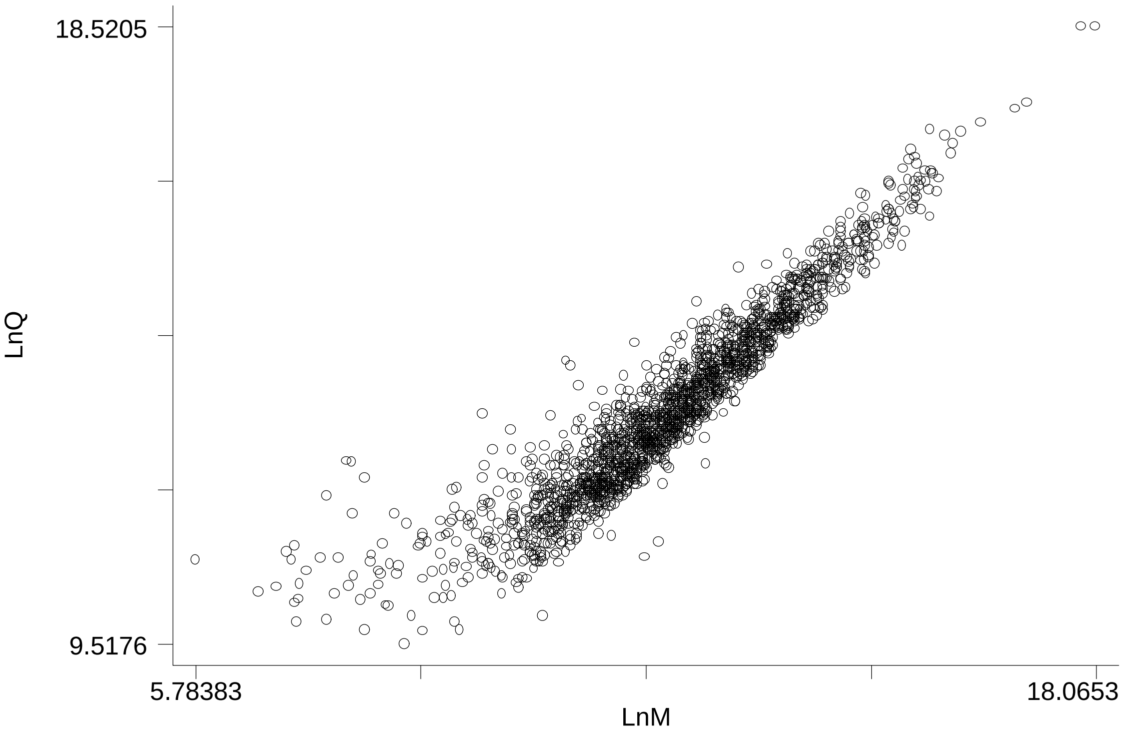
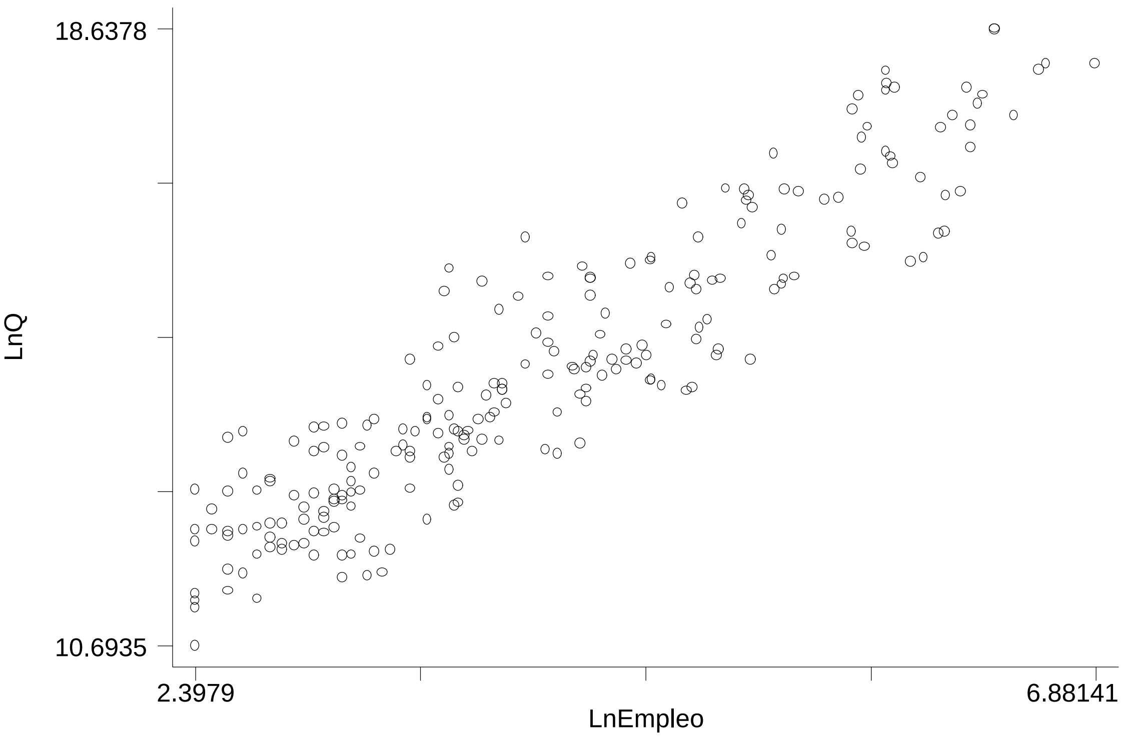
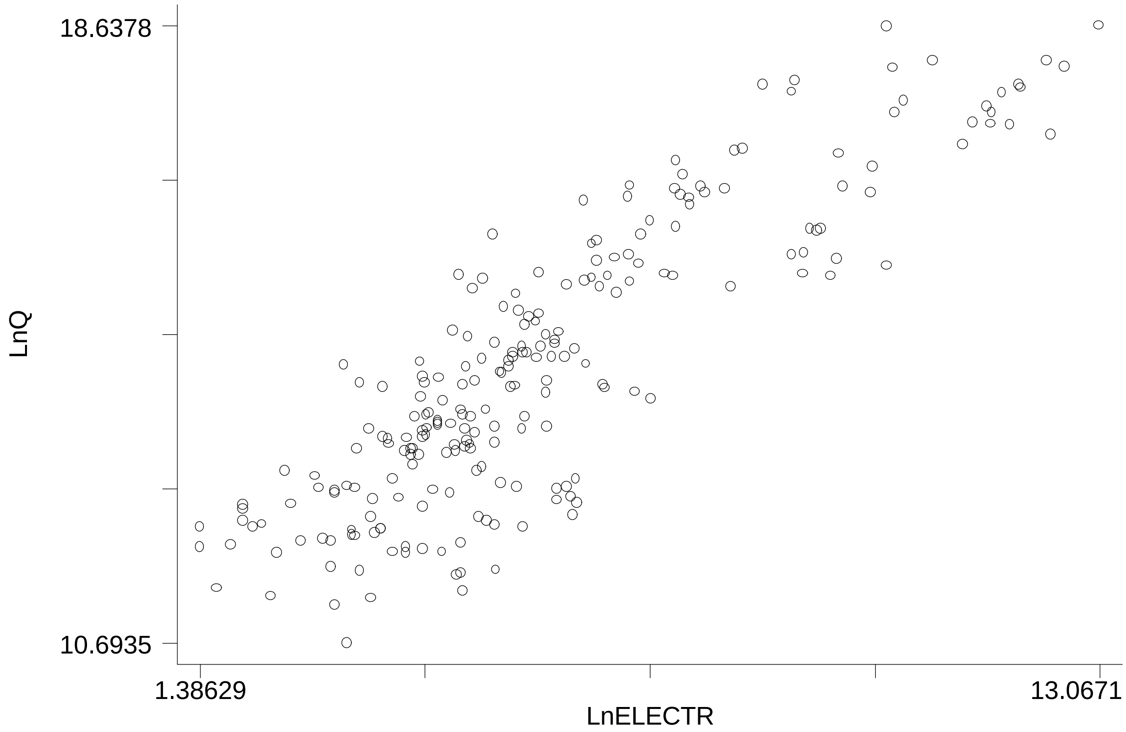


Figure A.2 – Plots sector S7 (reduced sample): Lnempleo, Lnm, Lnelectr




18.6378
LnQ
10.6935
1.38629
13.0671
LnELECTR

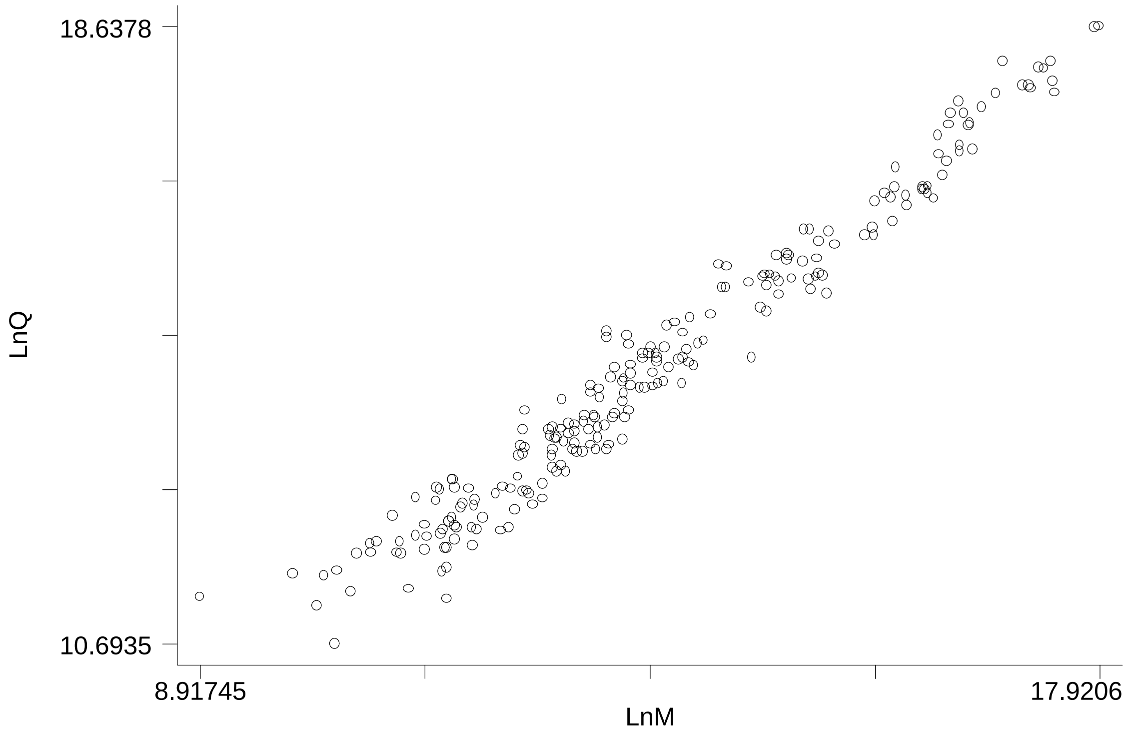

18.6378
LnQ
10.6935
8.91745
17.9206
LnM

Figure A.3 - Error density distribution estimates and frequencies: sector S2

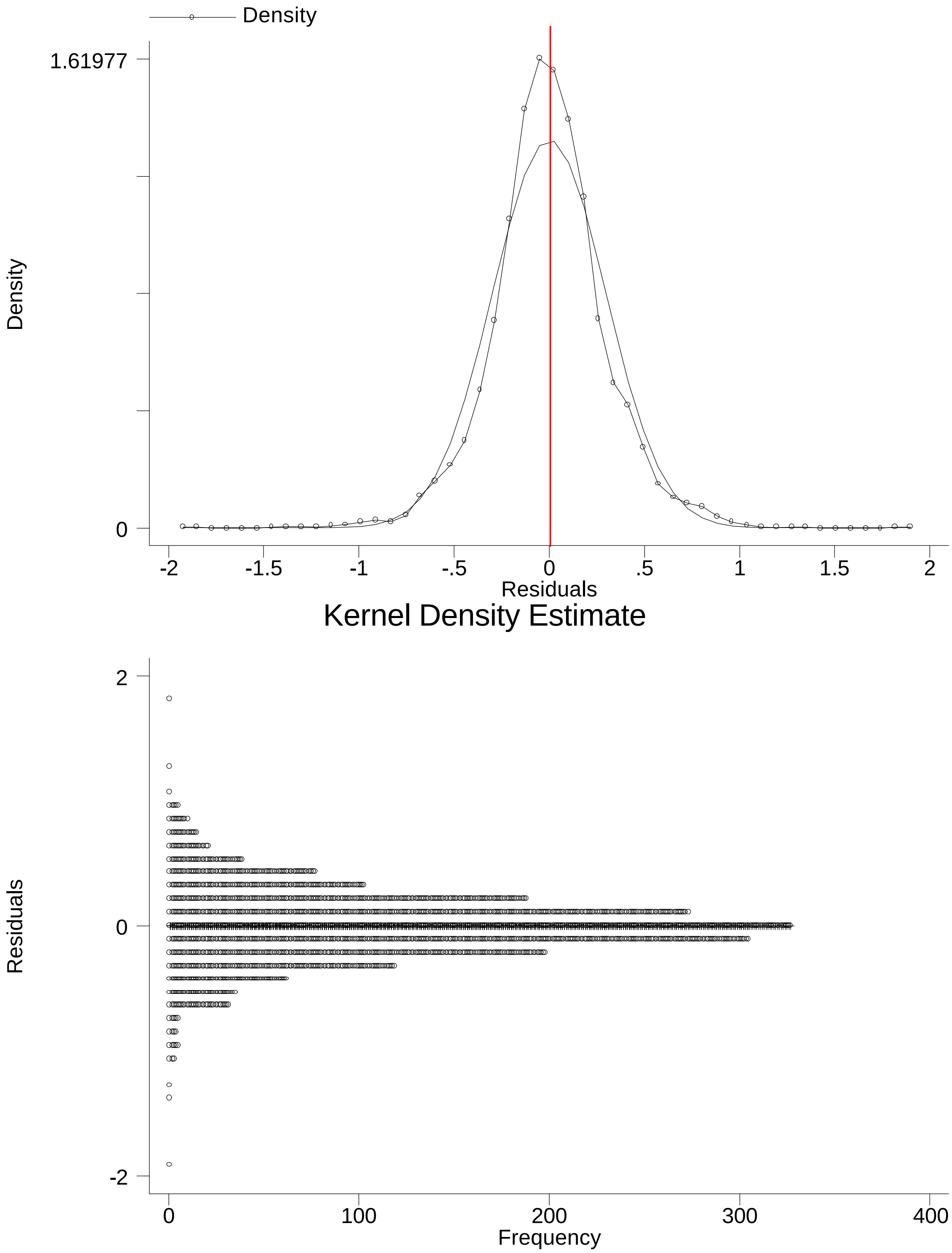


Figure A.4 - Error density distribution estimates and frequencies: sector S8

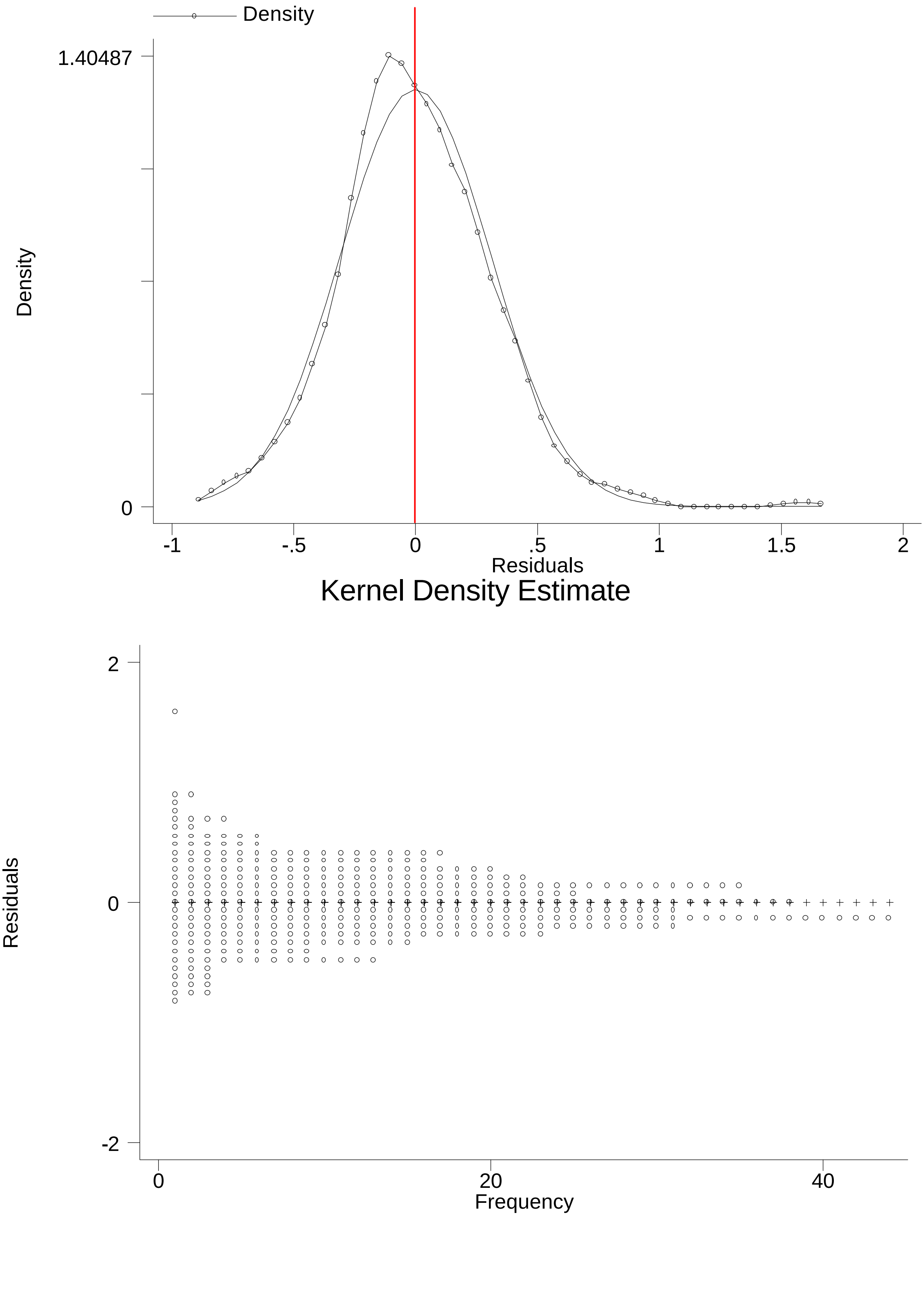


Figure A.5 - Error density distribution estimates and frequencies: sector S9 (no inefficiency)

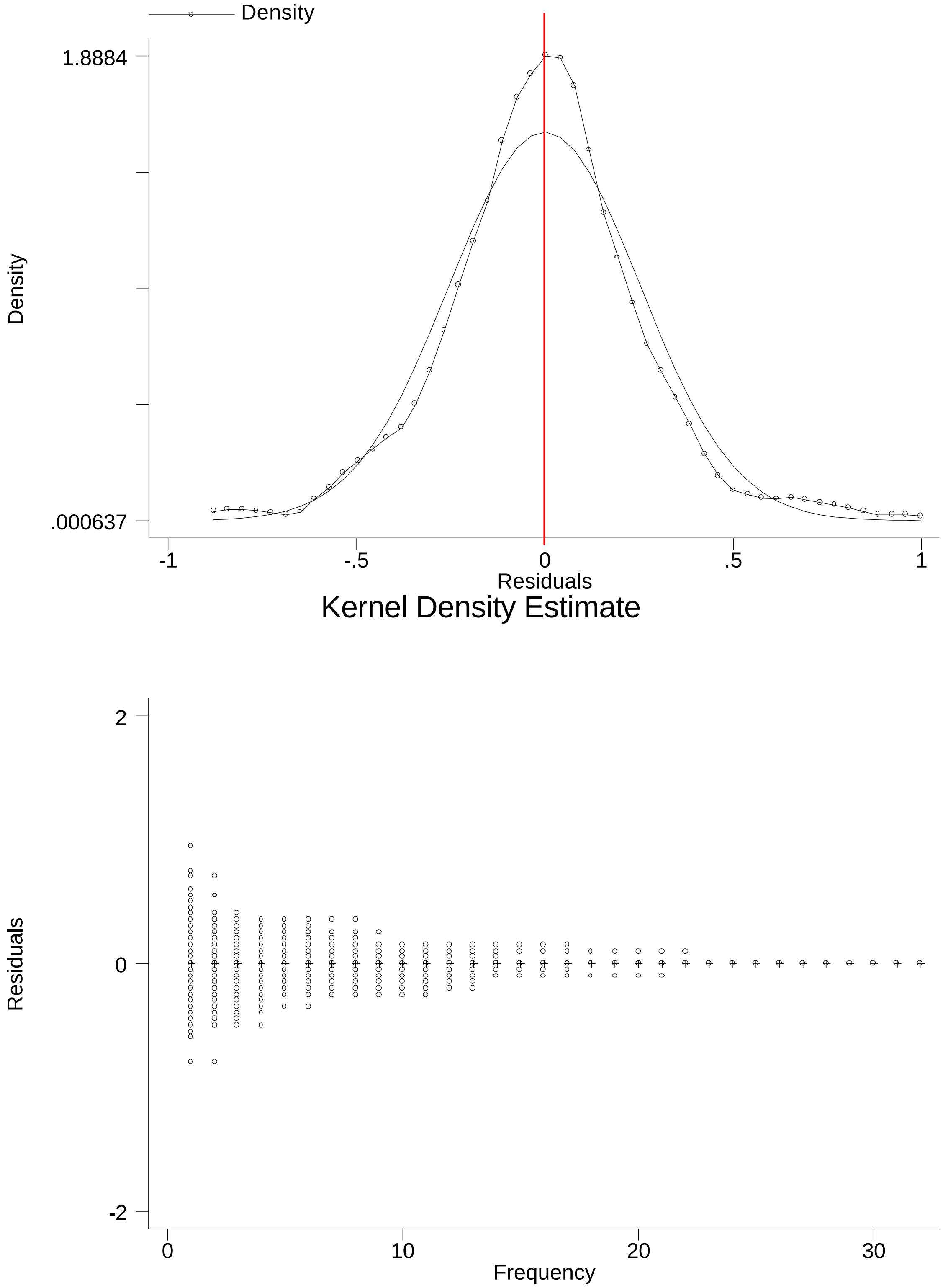


Figure A.6 - Efficiency distribution per region

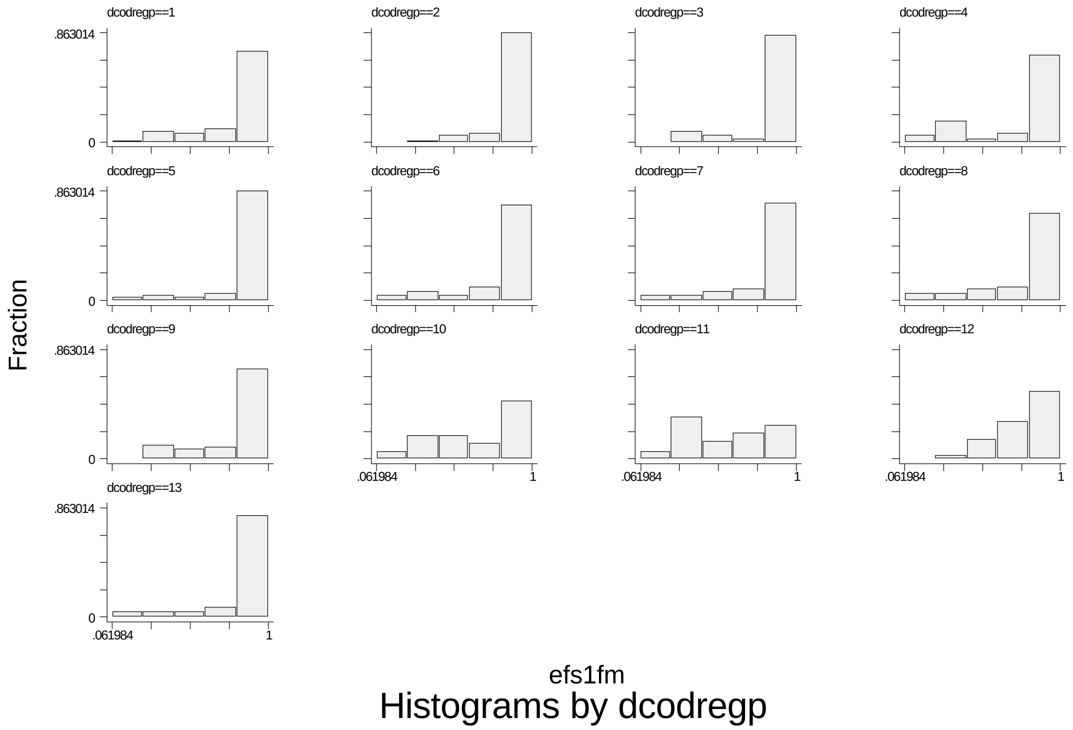


Figure A.7 - Efficiency distribution per sector: S1

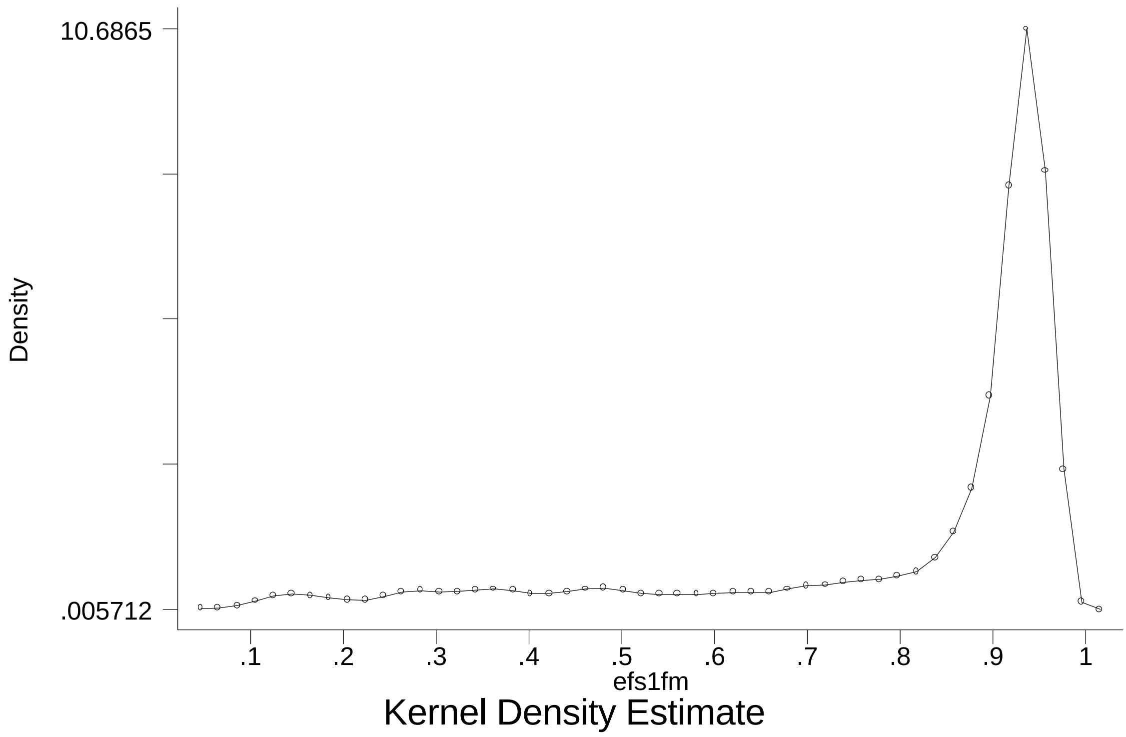


Figure A.8 - Efficiency distribution per sector: S2

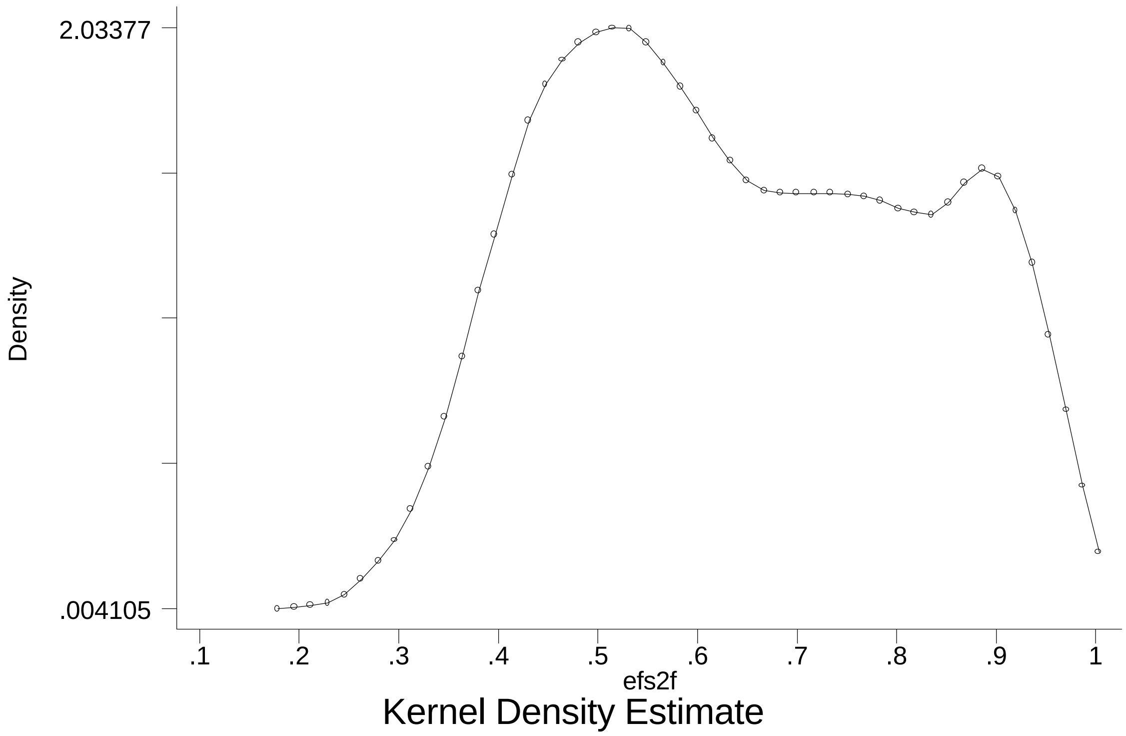


Figure A.9 - Efficiency distribution per sector: S3

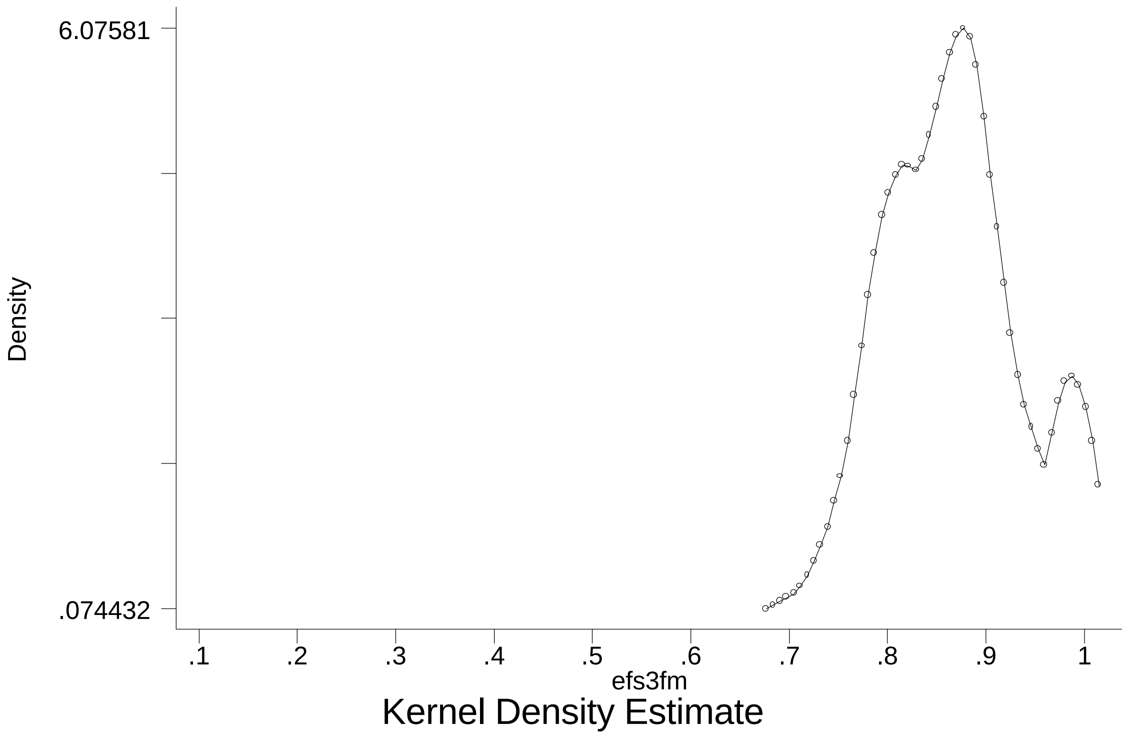


Figure A.10 - Efficiency distribution per sector: S4

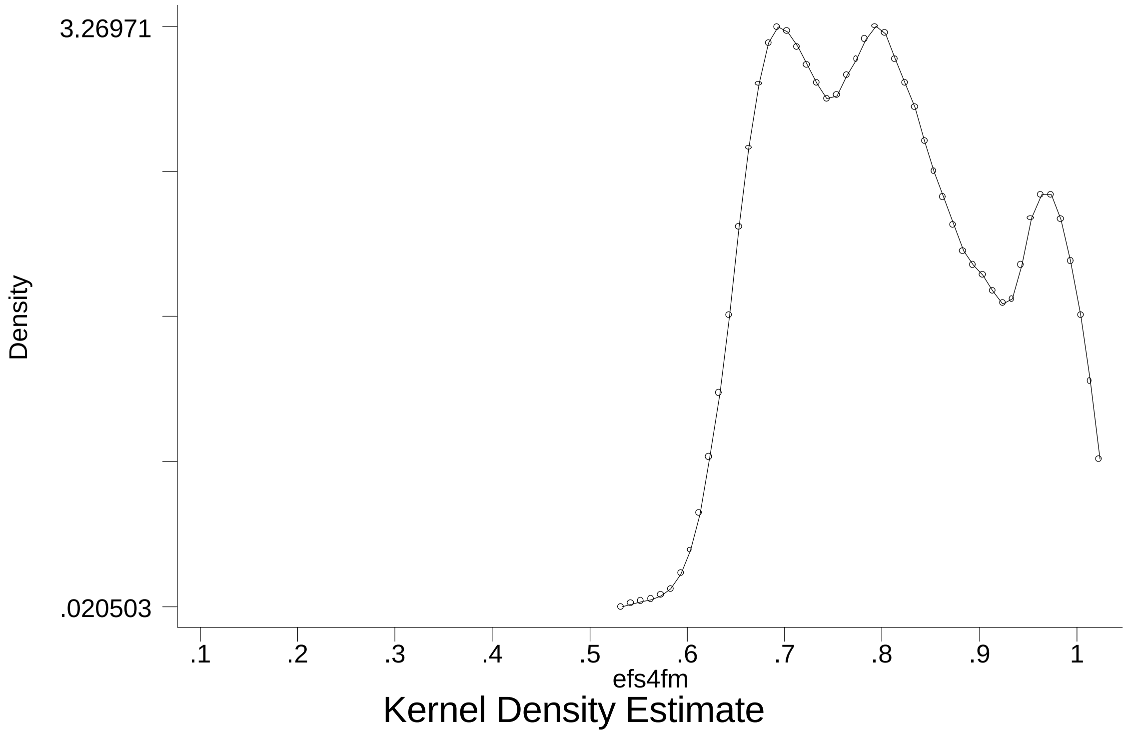


Figure A.11 - Efficiency distribution per sector: S5

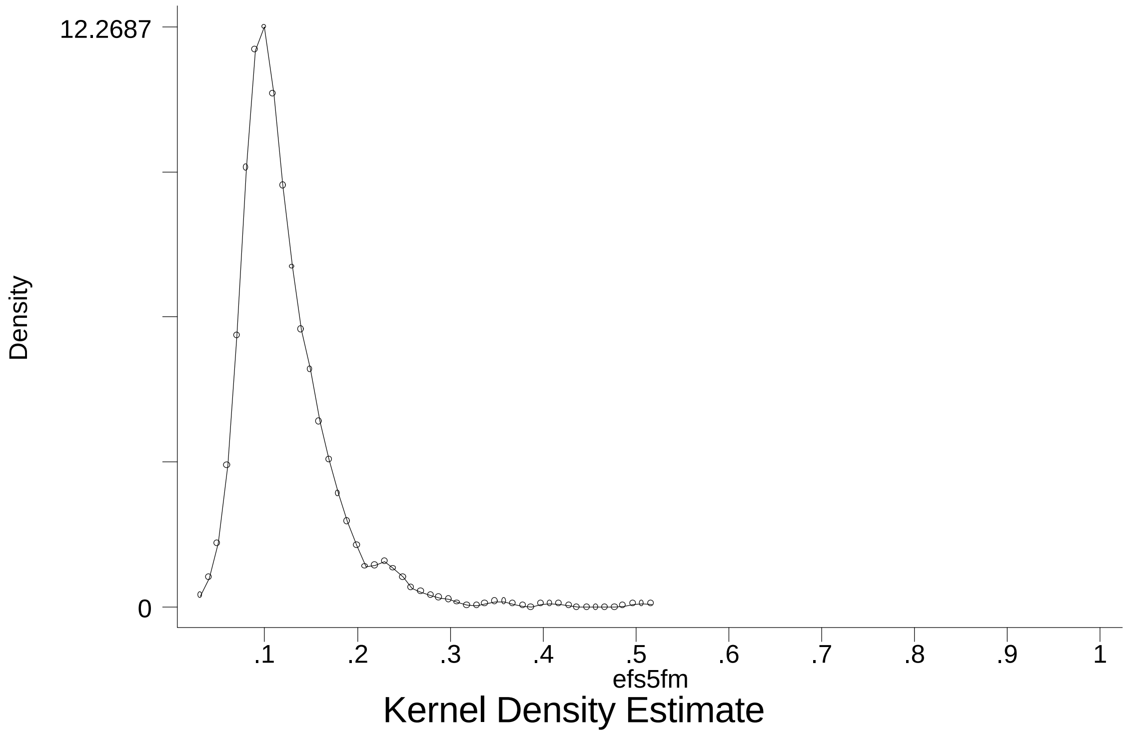


Figure A.12 - Efficiency distribution per sector: S6

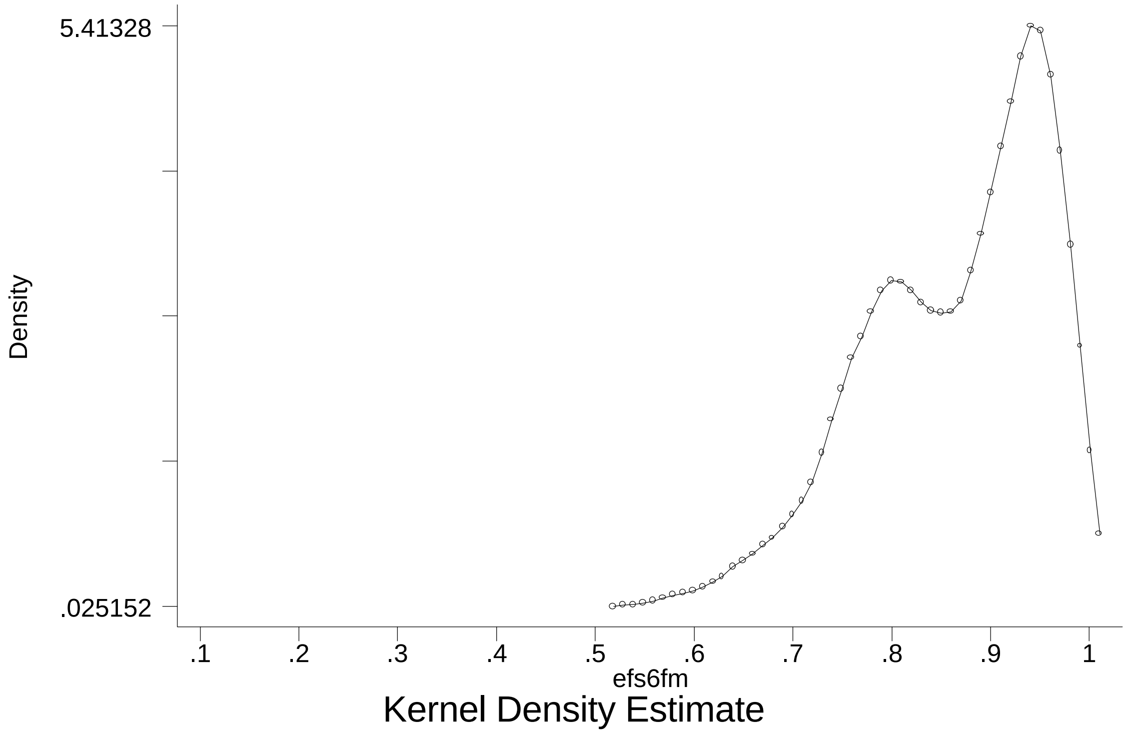


Figure A.13 - Efficiency distribution per sector: S7

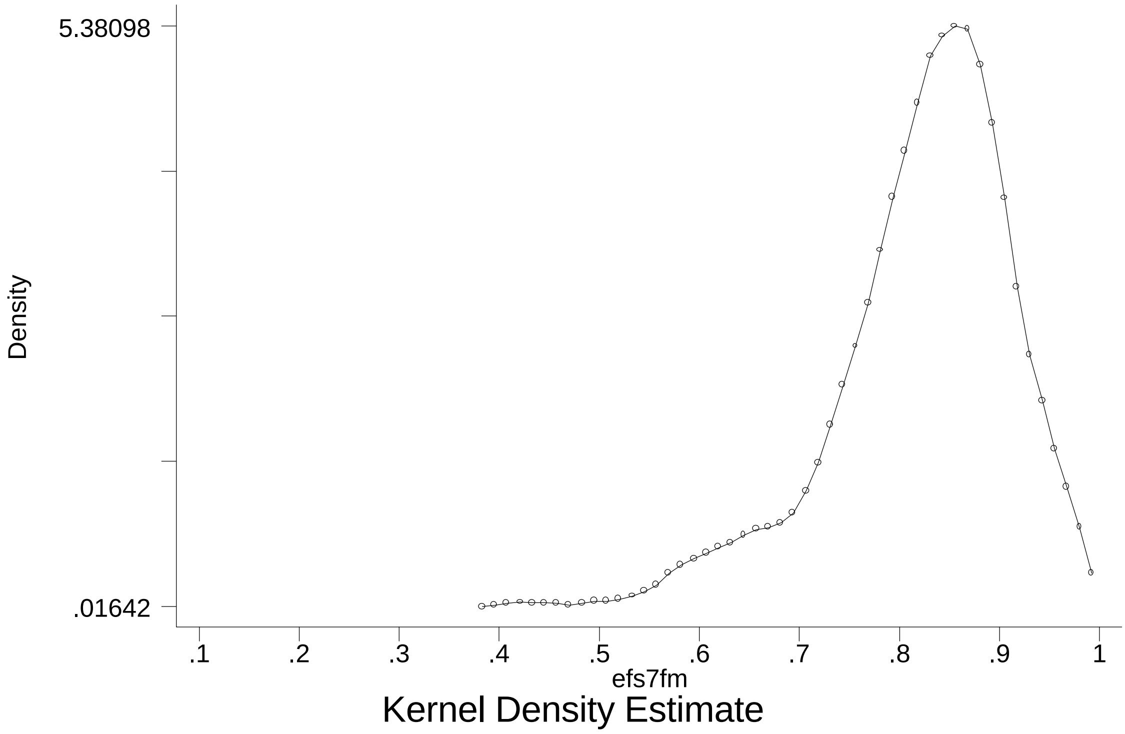


Figure A.14 - Efficiency distribution per sector: S8

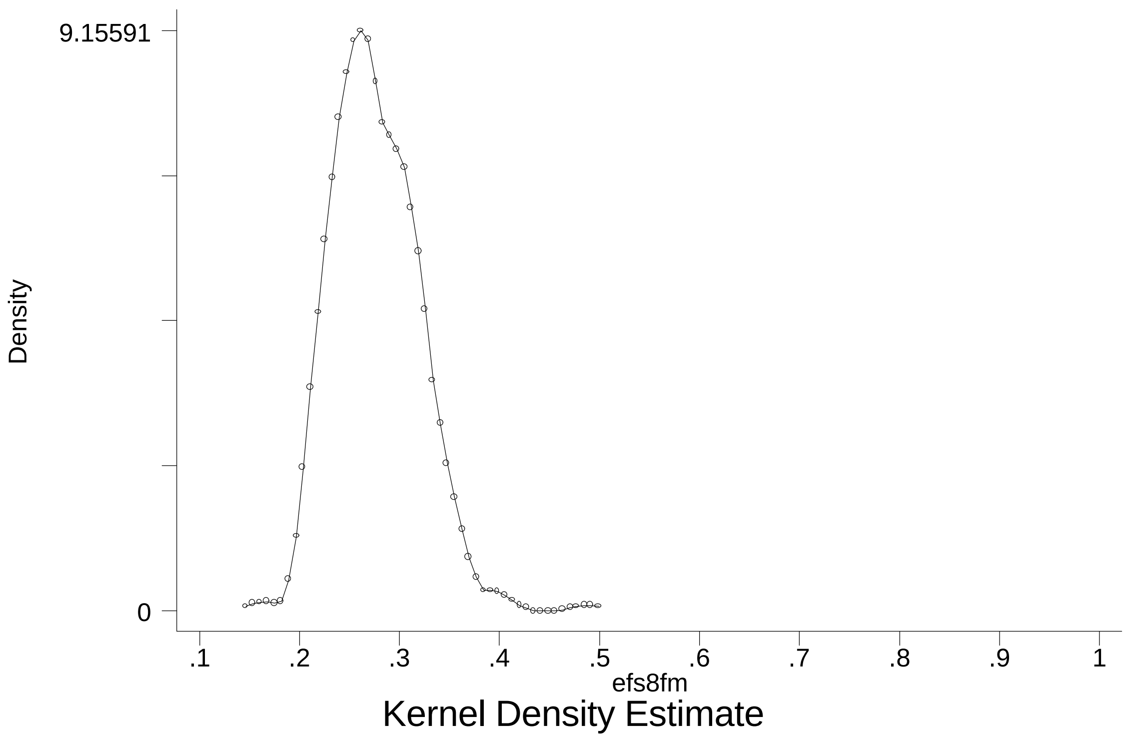


Figure A.15 - Estimation of distribution of skill ratio: pooled sectors

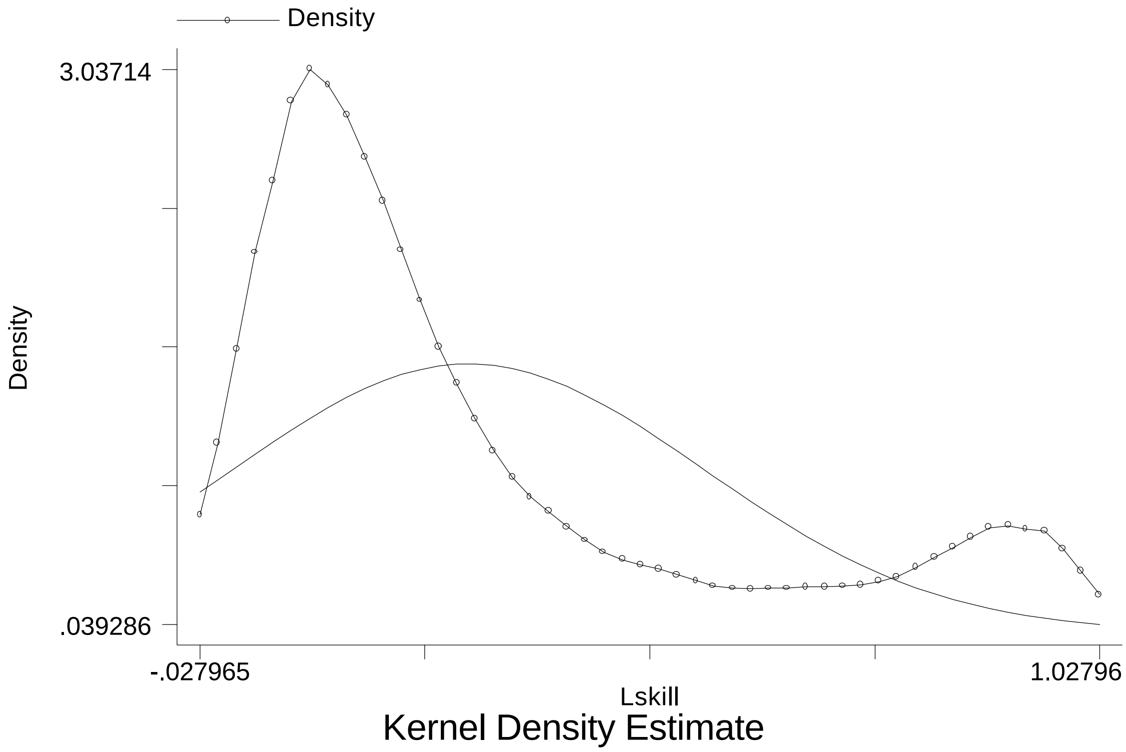
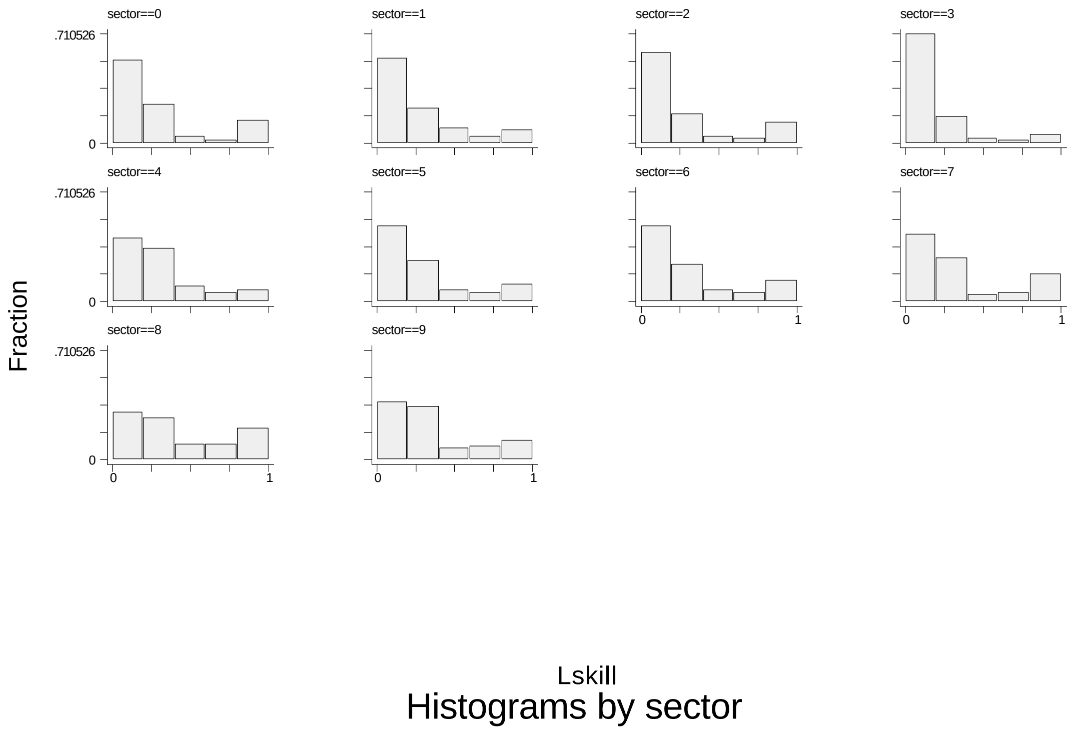


Figure A.16 - Distribution of skilled workers per sector



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