University of São Paulo
"Luiz de Queiroz" College of Agriculture

Essays on sugarcane

Rafael Lopes Jacomini

Thesis presented to obtain the degree of Doctor in Science. Area: Applied Economics

Piracicaba
2017

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Essays on sugarcane

versão revisada de acordo com a resolução CoPGr 6018 de 2011

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1. Cana-de-açúcar 2. Produtividade total de fatores 3. Eficiência 4. Transmissão assimétrica de preços I. Título

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EPIGRAPH

$$\boldsymbol{epif} = \{(\boldsymbol{x}, \boldsymbol{\mu}) : \boldsymbol{x} \in \mathbb{R}^{\boldsymbol{n}}, \boldsymbol{\mu} \in \mathbb{R}, \boldsymbol{\mu} \geq \boldsymbol{f}(\boldsymbol{x})\} \subseteq \mathbb{R}^{\boldsymbol{n+1}}$$

CONTENTS

RESUMO

Ensaios em cana de açúcar

Esta tese foi elaborada contendo uma introdução, seguida de dois capítulos independentes, cada um deles sendo um estudo de uma questão empírica diferente sobre o setor canavieiro brasileiro. O objetivo do estudo no capítulo 2 é analisar a produtividade das usinas de cana-de-açúcar do Estado de São Paulo no período pós-2008. Para avaliar as mudanças na produtividade foi utilizada uma abordagem de produtividade total de fatores (PTF), combinada com modelos estocásticos de fronteira e, em seguida, o crescimento da PTF entre 2010 e 2015 foi decomposto em quatro componentes: progresso técnico; mudança na eficiência técnica; mudança na escala de produção e mudança na eficiência alocativa. Os resultados parecem consistentes e indicam uma perda de eficiência para as usinas no período analisado, bem como destacam a importância do capital para as usinas, indicando que os problemas financeiros podem ter resultado em redução na produtividade neste setor. O capítulo 3 apresenta uma análise da existência de uma transmissão assimétrica de preços entre produtores e mercados varejistas de açúcar refinado no Estado de São Paulo, considerando aspectos como direção, magnitude e a velocidade de transmissão de preços. A análise empírica utilizou médias mensais de preços para o período de maio de 2003 a fevereiro de 2015 e os resultados sugerem que a transmissão de choques é bidirecional. Testes formais sugerem que a hipótese de simetria na transmissão de preços, tanto a curto como a longo prazo, do varejo para os produtores, não pode ser rejeitada.

Palavras-chave: Cana-de-açúcar; Eficiência; Produtividade total de fatores; Modelo de fronteira estocástica; Preços do açúcar; Transmissão assimétrica; Mercado de São Paulo

ABSTRACT

Essays on sugarcane

This thesis contains an introduction followed by two independent chapters, each of them dealing with a different empirical issue of Brazilian sugarcane sector. The aim of the study in chapter 2 is the productivity of São Paulo state sugarcane mills in the post-2008 period. To evaluate the productivity change, a total factor productivity (TFP) approach combined with stochastic frontier models were used and then the TFP growth between 2010 and 2015 had been decomposed into four components: technical progress; change in technical efficiency; change in the production scale and change in the allocative efficiency. The results seem to be consistent and indicate an efficiency loss for the mills over the analyzed period, as well highlighted the importance of capital for the mills, indicating that financial problems can lead to productivity losses in this sector. Chapter 3 presents an analyze the existence of asymmetric price transmission between producers and retail markets for refined sugar at the State of Sao Paulo, considering aspects such as direction, magnitude and speed of price transmissions. The empirical analysis used monthly averages of prices for the period from May 2003 to February 2015 and the results suggest that the transmission of shocks is bidirectional. Formal tests suggest that the hypothesis of symmetry in price transmission both in the short and long-run from retail to producers cannot be rejected.

Keywords: Sugarcane; Efficiency; Total factor productivity; Stochastic frontier model; Sugar prices; Asymmetric transmission; Market of Sao Paulo

1. INTRODUCTION

The sugarcane sector has a significant importance for the Brazilian economy. In terms of GDP, the crop year 2013/2014 contributed with 43.4 billion US dollars, while its contribution to employment was also significant, being responsible for something around 1.3% to 2.2% of the total employment in Brazil (Neves and Trombin 2014).

The sugarcane is an input for two important commodities: ethanol and sugar. Brazil is the second major ethanol producer, and first of sugarcane ethanol. However, this production is primarily for domestic consumption. Brazil is also the major sugar producer and exporter, with 67% and 71% of its sugar production exported between 2010 and 2015. Brazil is responsible for around 50% of the sugar in the international market and the commodity is important for the Brazilian list of exports; in 2013, it was the 5th item in this list in terms of exported value, contributing US$12 billion in export revenue (UNICA 2015).

Studies about the effect of exogenous events to the sugarcane sector, such as the sector's deregulation that started in the 1990s, the fall of international price plus bad financial situation for the sugarcane mills in the period that followed 2008, contribute to a better understanding of their dynamic effects, subsidizing policymakers.

This thesis evaluates and discusses two issues related to the sugarcane sector. The first is presented in Chapter 2 and discusses the mill's efficiency in the state of São Paulo, at the post-2008 crisis. The evolution of total factors' productivity is evaluated and interpreted, by splitting the evolution of the total factor productivity into four components. This is expected to provide a better understanding of the challenges faced by the sugarcane sector through the period of the analysis.

Chapter 3 presents a study of the dynamic of sugar prices, which it is about asymmetric price transmission between producer and retail prices for the refined sugar in the Brazilian state of São Paulo.

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UNIÃO DA INDÚSTRIA DE CANA-DE-AÇÚCAR – UNICA, banco de dados, Preço médio pago para cana-de-açúcar entregue pelos fornecedores no Estado de São Paulo, Available in < http://www.unicadata.com.br/listagem.php?idMn=61/> . Access in: July 11th. 2015.

2. TOTAL FACTOR PRODUCTIVITY OF BRAZILIAN SUGAR CANE MILLS IN THE POST-2008 CRISIS PERIOD

Abstract

The Brazilian sugarcane sector in the post-2008 period experienced major financial problems that led to bankruptcy of several mills that led to productivity loss in operating mills. Considering the importance of this sector for the Brazilian economy, this paper evaluates if the mills in São Paulo State, which is the main sugarcane producer, experienced a decrease in their productivity. To evaluate this, a total factor productivity (TFP) approach, combined with stochastic frontier models was used. The growth in TFP between 2010 and 2015 was disaggregated into four components: technical progress; change in technical efficiency; change in production scale, and change in allocative efficiency. The results seem to be consistent and suggest efficiency loss for the mills over the analyzed period. In addition, it highlights the importance of capital for the mills, suggesting that financial problems has resulted in productivity losses in this sector.

Keywords: Sugarcane; Efficiency; Total factors productivity, Stochastic frontier model

2.1 Introduction

The Brazilian sugarcane sector presented a strong growth during the first half of the 2000s, when the sector presented an average annual growth rates of 8% between the crop years 1999/2000 and 2007/2008, resulting in mean annual growth of 7% for sugar and 9% for ethanol. Following the global financial crises of 2008, the sector then went through deceleration. One of the most important causes of this change has been attributed to the sudden lack of financial resources to pay for a high foreign exchange debt, acquired when the supply of financial resources abounded in the international market. Some can argue that this decline occurred solely due to bankruptcy; however, loss in productivity could also be a part of the problem faced by the Brazilian sugarcane sector. In order to properly evaluate the importance of the productivity hypothesis, a total factor productivity (TFP) analysis emerges as a good alternative.

The main questions raised by this work include: given the crisis scenario, are the sugarcane firms still operating efficiently? Have the improvements in efficiency helped the sector maintain its good performance in the international market? Did the crisis have significant effects on production and efficiency throughout the sector? Were its adverse effects limited to less efficient firms in terms of production and planning? The answer to these questions can provide useful information for businesses and policymakers, and suggest scenarios for change that could aid the sector towards recovery. Total factor productivity

(TPF) analysis is particularly useful to investigate the efficiency's trajectory over time. In addition, if productivity changes are broken into components, the analysis becomes even more useful as it helps to draw policy recommendations.

There have been several drivers of the sector's growth addressed in the relevant literature. These include high commodity prices along with the expansion in sugar consumption in the international market, a higher importance attributed to sustainable oil fuel alternatives, and the expansion of the national flex fuel fleet. The positive economic scenario resulting from these drivers encouraged firms to take more loans and increase production capacities. In 2008, the sector had problems due to the global financial crisis and to the discovery of oil in Brazilian pre-salt layer. The government started to control gasoline prices[1] to contain inflation and for political reasons. These controls hindered the production of ethanol, which due to the flex fuel technology, is a good substitute for gasoline. Concurrently, international sugar prices started to drop in 2011 and 2012. The Brazilian government also cut gasoline taxes, a move that had another negative impact on the national sugarcane sector (Dias et al., 2015; Neves and Trombin, 2014).

There are different ways to justify the importance of this topic. It can be due, for example, to the important role assumed by the sugarcane sector in Brazil's economy in terms of GDP and employment. The sector's GDP for the crop year 2013/2014 was around 43.4 billion US dollars. Moreover, its contribution to the Brazilian labor market is significant. In 2013, for example, the sector employed 1.3% of the labor force, without considering seasonal jobs during crop season, which accounted for 61.5% of the employment in the entire sector (Neves and Trombin, 2014).

The Brazilian sugarcane industry is also highly competitive in the sugar international market and has been the leading global producer and exporter of both sugar and sugarcane ethanol for more than two decades.

Brazil is the only country in the world that has developed a large-scale production and consumption system of ethanol fuel, mainly for flex fuel vehicles, as an alternative to fossil fuels. In 2015, around 88.4% of licensed cars and commercial light vehicles in Brazil were flex fuel, able to run on ethanol, gasoline or a mix of both. This technology can be considered "green", as ethanol is based on a renewable resource, in this case, the sugar cane (ANFAVEA, 2015; CNI, 2012).

[1]This policy had a negative impact on Brazil's national oil company (Petrobras), leading to losses due to the practice of prices below the international market.

Ethanol production is primarily for domestic consumption. Sugar, on the other hand, is mainly destined to the export market, with between 67% and 71% of Brazilian sugar production exported between 2010 and 2015. Brazil is responsible for approximately 50% of the sugar in the global market, making this commodity an important item in the Brazilian exports list; in 2013, it was the 5th item in the list in terms of value, contributing US$12 billion in export revenues (UNICA, 2015).

Because of this scenario, the Brazilian milling capacity had a significant decrease with several mills in Brazil going into bankruptcy. Since the beginning of the crisis, about 14% of Brazilian mills closed, and it was expected this number to increase about 3 % in the crop year 2015/2016 (UNICA, 13/07/2015).Some studies contributed to our comprehension of the sector changes since the crisis, these include: Neves and Trombin, (2014), where the economic conditions for the sector were analyzed, indicating their evolution and challenges; and Dias et al (2015), which analyzed the sector's post-2008 crisis in the Brazilian state of Mato Grosso do Sul, from the perspective of the New Institutional Economics and Transaction Cost Economics. Although these and other studies refer to or discuss the sector's efficiency, none have formally analyzed the issue using production data. Addressing this deficiency in literature is the main aim of this paper.

Recent analyses of total factor productivity (TFP) in literature have had various motivations or purposes. Pires and Garcia (2012) focused on comparing productivity at the country level, aggregating all economic activities. Other studies focus on analyzing the evolution of specific economic sectors, such as Braganolo and Barros (2015), for example, who focus on the Brazilian agriculture industry. For the sugarcane sector, there have been papers focusing on producer countries such as India (Singh and Agarwal 2006), Pakistan (Raheman, Abdul and Afza 2009) and Brazil (Salgado et al., 2013, Salgado et al., 2013, Pereira and Silveira, 2016). Although these studies have similar objectives (total factor productivity and its evolution in the case of Pereira and Silveira), there are distinctions in the methods used.

Salgado Junior et al. (2013) and Salgado Junior et al. (2014) used the Data Envelopment Analysis (DEA) to compare the efficiency of Brazilian sugarcane mills and relate the predicted efficiency with the sugarcane mills' size, and confirm whether the efficiency is spatially correlated. This study used as input the total grinded sugarcane and, as output, sugar and ethanol production, where the source for all data was the year book "Anuário da Cana 2008". These studies concluded that most of the most efficient mills in Brazil are in the state of São Paulo, however, the size and efficiency correlation effect is not so clear, since one study concluded that there may be a positive relation between size and efficiency, but another found no association between these variables.

Pereira and Silveira (2016) evaluated a TFP decomposition for sugarcane mills in Centre-South Brazil considering annual data for a period before the financial crisis: 2001 to 2008, and using a DEA and a Malmquist index to measure productivity evolution. The data was from 17 mills that used grinded sugarcane and number of workers as inputs to obtain sugar and ethanolproduction, having UNICA and primary data as the sources. This study concluded that mills do not adopt nor create radical innovations, but follow already tested and proven technologies that spread to others.

Unlike other studies with similar purposes, this study evaluates TFP evolution and decomposition in the post-2008 crisis period using different approaches. Instead of using DEA, a Stochastic Frontier Analysis (SFA) that allows decomposing the error term in an inefficiency part and a stochastic part is used. The TFP decomposition method applied in this study was suggested by Bauer (1990) and Kumbhakar (2000), and it can distinguish between four components in TFP growth, namely, technical progress, changes in technical efficiency, production scale and allocative efficiency. Another difference is the use of post-2008 data. More specifically, the data used covers the period from 2010 to 2015.

2.2 Methodology and Data

2.2.1 Stochastic Frontier Analysis (SFA)

The efficiency analysis literature is dominated by either of the following two methods, the data envelopment analysis (DEA) and the stochastic frontier analysis (SFA). DEA is a nonparametric approach that uses mathematical programing to construct the bounds of the technology set as a piece-wise linear frontier. This approach is attractive because it does not require the specification of a functional form. However, it is a deterministic approach that attributes all deviations from the frontier to inefficiency without allowance for noise or measurement errors. As a result, the bulk of analyses using DEA does not incorporate a statistical model nor provides confidence intervals for efficiency estimates, unless bootstrapping methods are used. SFA, on the other hand, involves econometric analyses (maximum-likelihood or Bayesian) and requires the specification of a functional form for the technology and the specification of distributional assumptions for the noise and inefficiency components in a composed error structure (Coelli et al., 2005).

There are numerous studies comparing results from the two approaches (e.g. Ferrier and Lovell, 1990; Warp, 1998; and Chen, 2002). These show that there can be significant differences in efficiency scores between them and neither method can be easily judged to be superior to the other at all cases. In this study, we use present and compare results from both methods.

Stochastic frontier analysis (SFA) has been used to analyze any problem where the observed outcome deviates from the potential outcome using econometric models. Traditionally it is applied to analyze production, cost and profit functions. In the case of the production function, the potential output is considered as a maximum possible production, given the inputs and the technology, and the divergence between the real output and the potential one is attributed to technical inefficiency (Kumbhakar, 2015, Coelli et al., 2005).

Some examples of applications of SFA to macroeconomics issues include Pires and Garcia (2012) who compare growth between developed and developing nations and Arazmuradov, Martini and Scotti (2013) where the growth determinants for the former Soviet Union countries are analyzed. Other studies focused on microeconomic and industrial organization issues. For example; Lang and Welzel (1999) analyzed the efficiency of merged banks in Germany before and after the merging; Cullinane, Song and Gray (2002) evaluated the positive effects of deregulation and the relation between size and efficiency in Asian container ports; Kraft and Tirtiroglu (1998) who studied the efficiency and profitability of banks in Croatia before the liberalization of the sector; and Battese and Broca (1997) estimated the efficiency of wheat farmers in Pakistan.

The modeling approaches for both, SFA and TFP decomposition used in this study follow the approach described by Kumbhakar (2000) and Pires and Garcia (2012), which was based on the models proposed by Aigner, Lovell e Schmidt (1977), Meeusen and van den Broeck (1977), Pitt and Lee (1981) and Schmidt and Sickles (1984). This approach has been widely used in the literature; see, for example, Arazmadurov, Martini and Scotti (2014) and Thakur and Jain (2014),

In a nutshell, the aim of the stochastic production frontier is to provide estimates for the TFP components and for the technical efficiency, with the general model for the stochastic production frontier given by the equation (2.1).

$$y = f(t, x, \beta). \exp(v) . \exp(-u) , u \geq 0, \tag{2.1}$$

where y is a vector of output quantities produced by the mills, t represents the time periods, x is a vector of production factors, β is a vector of the parameters to be estimated, and v and u are both vectors for error components. The component v is the random part of the error with a symmetric distribution and captures the estimation disturbances and the exogenous shocks, while u captures a downward deviation from the production frontier and represents inefficiency.

Subscripts are added to explicitly distinguish between firms and time periods, the stochastic production frontier for each mill i, in the period t, the expression can be represented by equation 2.2:

$$y_{it} = f(t, x_{it}, \beta). \exp(v_{it}) . \exp(-u_{it}) ; \qquad (2.2)$$
$$i = 1, \dots, N, \ t = 1, \dots, T.$$

Where $f(t, x_{it}, \beta)$ is the deterministic part of the model, while for the stochastic part it is assumed that $v \sim iid\ N(0, \sigma^2)$ and u is a non-negative probability distribution. Both error components v and u are independent from each other and vector x is supposed to be exogenous, and this model can be estimated by maximum-likelihood techniques. The most common distributions for u are the half-normal, truncated-normal and exponential (Kumbakhar 2015, Coelli et al 2005). However, other distributions can be used, e.g. a gamma distribution (Greene 1990). Among the three most common distributions for u, the truncated-normal distribution has one extra parameter when compared with the others. This characteristic makes it more flexible in terms of the shape of inefficiency distribution. When $u \sim NT(\mu, \sigma_u^2)$, i.e. u has a normal-truncated distribution with an average μ different from zero, and its time-variant inefficiency term is as shown in equation (2.3) (Pires and Garcia 2012).

$$u_{it} = \exp[-\eta(t - T)] . u_i, u_{it} \geq 0 \ e \ i = 1, \dots, N \ e \ t \ \in \tau(i), \qquad (2.3)$$

where $\tau(i)$ represents the T_i time-periods for which there are observations available for mill i, among the T periods of the panel, letting $\tau(i)$ contain all time-periods of the panel or just part of it. In other words, it allows the data used to be an unbalanced panel. The term η represents the technical inefficiency behavior over time; when η is not statistically different from zero the technical inefficiency is not time-variant. By this construction, technical inefficiency increases over time when $\eta > 0$, or decreases over time when $\eta < 0$, it may also be the same for all the i mills in the sample, depending on the model chosen.

2.2.2 Functional form

We did not assume that production technology is a translog function, as done by Kumbhakar (2000) or Pires and Garcia (2012); nor do we assume that it is a Cobb-Douglas, as in Coelli et al. (2005), but we assume that the technology function can be a translog, a Cobb-Douglas, or a function in between the two forms. Since a Cobb-Douglas can be defined as a special case of a translog function, where all parameters for the square terms and the interaction between two terms are equal to zero, there are functions between these two that are stricter than a translog, but less strict than the Cobb-Douglas that could be tested.

The less strict technology function considered in this paper is the translog with three inputs, capital (*K*), labor (*L*) and land (*G*), which can be written according to equation (2.4):

$$
\begin{aligned}
ln\, y_{it} = {} & \beta_0 + \beta_t t + \beta_K\, ln\, K_{it} + \beta_L\, ln\, L_{it} + \beta_G\, ln\, G_{it} + \frac{1}{2}\beta_{tt}\, t^2 + \frac{1}{2}\beta_{KK}(ln\, K_{it})^2 \\
& + \frac{1}{2}\beta_{LL}(ln\, L_{it})^2 + \frac{1}{2}\beta_{GG}(ln\, G_{it})^2 + \frac{1}{2}\beta_{KL}(ln\, K_{it})(ln\, L_{it}) + \frac{1}{2}\beta_{KG}(ln\, K_{it})(ln\, G_{it}) \\
& + \frac{1}{2}\beta_{LG}(ln\, L_{it})(ln\, G_{it}) + \beta_{Kt}[(ln\, K_{it})t] + \beta_{Lt}[(ln(L_{it})\, t] + \beta_{Gt}[(ln\, G_{it})t] \\
& + v_{it} + u_{it}.
\end{aligned}
\tag{2.4}
$$

The elasticities of factors *K, L* and *G* can be obtained from the derivatives of the equations above. If a translog technology is used, these elasticities are going to be specific for each mill in each period, which is not the case with the Cobb-Douglas functional form, where all mills share the same elasticity estimates. Although functional forms are tested in this paper, there is evidence in the literature that efficiency scores estimated by different functional forms are highly correlated (Atilgan, 2016).

2.2.3 TFP decomposition

Following the procedures in Pires and Garcia (2012), or Bauer (1990) and Kumbhakar (2000), it is possible to represent the growth rate of the TFP by a Divisia index.

This index is defined as the difference between the rate of change of the output and the rate of change of each input quantity index, as indicated in equation 2.5.

$$g_{TFP} = \frac{\dot{y}}{y} - s_K \frac{\dot{K}}{K} - s_L \frac{\dot{L}}{L} - s_G \frac{\dot{G}}{G}, \tag{2.5}$$

where, g_{TFP} is the TPF growth rate and s_k, s_L and s_G are the shares of capital, labor and land in the aggregate income, and the sum of s_k, s_L and s_G is equal to one. These components, s_k, s_L and s_G, can be understood as the percentage of production cost spent in each of the three production inputs.

Considering the deterministic part of the stochastic production frontier in (2.2), it is possible to derive the relationship between output growth, growth rates of the different inputs, technological progress and change in inefficiency:

$$\frac{\dot{y}}{y} = \frac{\partial \ln f(t, K, L, G, \beta)}{\partial t} + \varepsilon_K \frac{\dot{K}}{K} + \varepsilon_L \frac{\dot{L}}{L} + \varepsilon_G \frac{\dot{G}}{G} - \frac{\partial u}{\partial t}, \tag{2.6}$$

where, ε_K, ε_L and ε_G are the output elasticities for each production factor, with the returns to scale (*RTS*) given by $RTS = \varepsilon_K + \varepsilon_L + \varepsilon_G$. Where the contribution rate of each input for the return to scale is defined by:

$$\lambda_K = \frac{\varepsilon_K}{RTS}, \lambda_L = \frac{\varepsilon_L}{RTS}, \lambda_G = \frac{\varepsilon_G}{RTS}. \tag{2.7}$$

Defining the growth rate of the factors capital, labor and land ($\frac{\dot{K}}{K}$, $\frac{\dot{L}}{L}$ and $\frac{\dot{G}}{G}$) as g_K, g_L and g_G, respectively and by combining the results in (2.5), (2.6), and (2.7), it is possible to have the relationship in (2.8) (Kumbhakar, 2000 and Pires and Garcia, 2012):

$$\begin{aligned} g_{TFP} = TP - \dot{u} + (RTS - 1)[\lambda_K g_K + \lambda_L g_L + \lambda_G g_G] + [(\lambda_K - s_K) g_K \\ + (\lambda_L - s_L) g_L + (\lambda_G - s_G) g_G]. \end{aligned} \tag{2.8}$$

Therefore, it is possible to break down TFP growth (or change), into four distinct components, as follows:

i. The technical progress, given by $TP = \frac{\partial \ln f(t,K,L,G,\beta)}{\partial t}$;
ii. The change in technical efficiency, represented by $TE = -\dot{u}$;

iii. The change in the production scale, given by $PS = (RTS - 1)[\lambda_K g_K + \lambda_L g_L + \lambda_G g_G]$;

iv. The change in the allocative efficiency, given by $AE = [(\lambda_K - s_K)g_K + (\lambda_L - s_L)g_L + (\lambda_G - s_G)g_G]$.

TP (i) captures the trend of productivity change or an exogenous technical change, and $-\dot{u}$ (ii) indicates the rate at which inefficient producers move towards the production frontier. When (i) and (ii) are analyzed together, they represent overall productivity change, given the input quantities. The element (iii) in equation (2.8) shows the change in the TFP due to the change in scale components, and (iv) captures scale components' change considering the difference between their contribution rate to the scale and their share in the costs. The components (iii) and (iv) analyze the change in TFP with a given change in the inputs (Kumbhakar, 2000).

2.2.4 Data

The main data source for the mills in this paper was a yearbook called "*Anuário da Cana*" for the years 2010, 2011, 2012, 2013 and 2015[2]. The sample consists of 80 sugar mills in the state of São Paulo, Brazil. The total number of observations in the unbalanced panel data set is 193.

There are two groups of outputs: sugar and ethanol[3], which were aggregated into total recoverable sugar (TRS), which is the amount of sugar that can be extracted from the sugarcane, being the precursor of sugar and ethanol in a mill. We calculated the TRS using the output data from "*Anuário da Cana*", by transforming the production amount of each output in tons of TRS using a technical index provided by the CONSECANA[4] index, presented by the Bioenergy Producers Union – UDOP (2015).

The input source is also the year book "*Anuário da Cana*". Capital (K) is defined as total daily mill installed capacity for each mill in each year; labor (L) is the number of workers in industrial, management and agricultural activities, and the number of mill employees is not necessary; land (G) is the total cropped area in hectares and can include land

[2] The corresponding information of 2014 was identical to 2013, so it was not used.

[3] Not all mills can produce sugar, but all of them can produce ethanol using the same inputs.

[4] The CONSECANA index is used by mills to pay for sugarcane provided by other farmers, being an average of "sugar" produced by a ton of processed sugar cane.

belonging to the mill, to a shareholder, or to an independent supplier. Table 2.1 shows a summary of the outputs and inputs used in this paper.

Table 2.1: Statistical description of the variables (in level)

Variable	Obs	Mean	Std.Dev	Min	Max
TRS	193	353448.7	635387.7	25040.5	7872221
K	193	15372.1	27267.5	1100	327200
L	193	2156.5	3584.4	233	45723
G	193	31328.4	54102.3	2400	632851.7

Source: Authors analysis using data from "*Anuário da Cana*" (2010, 2011, 2012, 2013, 2015) and CONSECANA table to convert sugar and ethanol into *TRS*.

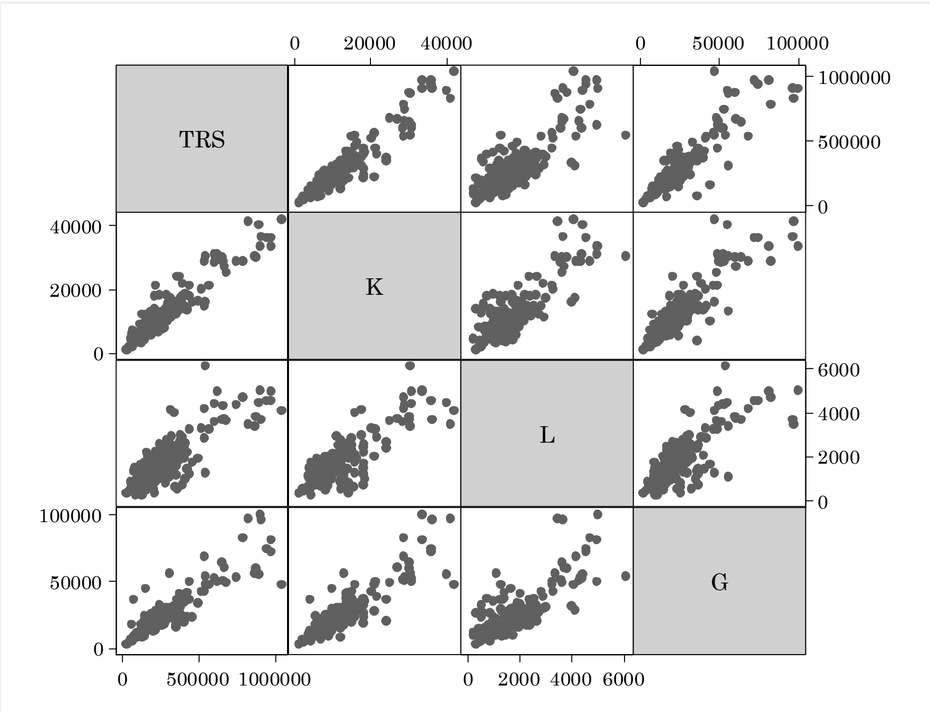

Figure 2.1: Output and input pairs graph matrix.

There is a high correlation between each pair of variables (output and input) as shown in Figure 2.1 and Appendix 1. The strong correlation between inputs could be due to a technical reason, a small elasticity of technical substitution between the inputs in the limit zero, as in a Leontief technology case. In this case, a small elasticity of technical substitution makes sense considering the nature of sugar and ethanol production and to the limited choices available for production technologies, especially in the short run.

The shares of capital, labor and land in aggregate income[5] came from different sources, even though they were measured in monetary values. The Brazilian inflation index IGP-M, provided monthly by the Getulio Vargas Foundation (FVG), was used to convert

[5] It was considered that the input participation in the aggregate income is equal to the cost of this input.

these values into comparable values, with the same base year. The converted data was used to calculate the shares for each mill using these prices and the amount of each input in the production for each mill.

For capital costs, the variable used was industrial capital costs (PECEGE – CNA, 2012), this variable allows different costs for raw and white sugar and for hydrated or anhydrous ethanol produced.

Labor costs are calculated as the sum of wages paid plus the costs of employment benefits in Brazil, which is around 80% according to Furtado (2015). In respect to wages, Hoffman and Oliveira (2008) calculated average wages used for industrial and agricultural jobs in the sugarcane sector in São Paulo, Brazil, which were the basis for labor contribution to the aggregated income values in this paper.

In São Paulo the mills pay sugarcane providers by the amount of TRS following referee prices in the Consecana-SP table (UNICA, 20XX), thus the land costs were measured according to this table using the sugarcane amount in weight used and transforming it into TRS. This strategy did not hinder the analysis given the strong relationship between land and total milling cane weight, presented in appendix 2[6].

Growth rates for inputs and outputs are shown in Tables 2.2 and 2.3. Capital is the only input that has shown consistent growth over time because of sunk costs. When a firm makes a decision to increase the installed production capacity, the machinery acquired cannot easily be used in another economic activity. However, land and labor do not have this dynamic.

Table 2.2: Growth rate statistics of TRS and Capital

Time variation	Number of Observ.	Growth Rate							
		TRS				Capital			
		max	min	mean	sd	max	min	mean	sd
2010-2011	40	0.710	-0.435	0.067	0.192	0.677	-0.126	0.025	0.135
2011-2012	34	0.368	-0.671	-0.117	0.175	0.3	-0.167	0.017	0.099
2012-2013	31	1.976	-0.198	0.124	0.349	0.636	-0.121	0.052	0.134
2013-2015	1	0.205	0.205	0.205	-	0.167	0.167	0.167	-

Source: Authors' own elaboration.

[6] Appendix 2 shows strong correlation between land and total milling cane, where land explains 97% of the total milling cane variations.

Table 2.3: Growth rate statistics of labor and land

Time variation	Number of Observ.	Growth Rate							
		Labor				Land			
		Max	Min	Mean	Std.Dev	Max	Min	Mean	Std.Dev
2010-2011	40	0.271	-0.689	-0.065	0.215	0.874	-0.446	0.098	0.258
2011-2012	34	3.223	-0.344	0.158	0.698	2.759	-0.238	0.226	0.648
2012-2013	31	1.945	-0.658	0.237	0.502	0.297	-0.475	-0.021	0.183
2013-2015	1	-0.298	-0.298	-0.298	-	0.544	0.544	0.544	-

Source: Author's own-elaboration.

2.3 Results and Discussion

The first step for a stochastic frontier model is choosing the technology function. In this paper, eleven technology equations were tested and compared. These include the translog function in its least restrictive or general form and other special cases with some restrictions in the parameters imposed. The functional forms tested have been used in literature, although most prior studies have considered only two inputs -- capital and labor. The inclusion of a third input, land in our case, increases the number of possible models and, therefore, some adjustments were made. For example, in literature, there are models without interaction between one input and the time variable, such as the Harrod neutral and Solow neutral in the case of capital and labor inputs, respectively. We will refer to the model without interaction between land and time variables as Land neutral. The set of restrictions tested in this study is shown in Table 2.4.

Table 2.4 Technology Functions

Function	Restrictions
Translog	–
Harrod neutral	$\beta_{Kt} = 0$
Solow neutral	$\beta_{Lt} = 0$
"Land" neutral	$\beta_{Gt} = 0$
Hicks neutral	$\beta_{Kt} = \beta_{Lt} = 0$
"Harrod-land" neutral	$\beta_{Kt} = \beta_{Gt} = 0$
"Solow-land" neutral	$\beta_{Lt} = \beta_{Gt} = 0$
"Hicks-land" neutral	$\beta_{Kt} = \beta_{Lt} = \beta_{Gt} = 0$
Translog without TP	$\beta_t = \beta_{tt} = \beta_{Kt} = \beta_{Lt} = \beta_{Gt} = 0$
Cobb-Douglas	$\beta_{tt} = \beta_{KK} = \beta_{LL} = \beta_{GG} = \beta_{KL} = \beta_{KG} = \beta_{LG} = \beta_{Kt} = \beta_{Lt} = \beta_{Gt} = 0$
Cobb-Douglas without TP	$\beta_t = \beta_{tt} = \beta_{KK} = \beta_{LL} = \beta_{GG} = \beta_{KL} = \beta_{KG} = \beta_{LG} = \beta_{Kt} = \beta_{Lt} = \beta_{Gt} = 0$

Source: Author's own elaboration.

All model variants presented in Table 2.4 were estimated by the same estimator, using Battese and Coelli 1992 model (BC 92), using the Bayesian information criteria (BIC) for model comparison. The results are shown in Appendix 3. The choice of estimator BC 92 was due to the formulation in equation (2.3), treating the inefficiency term u as a normal-truncated distribution, an approach that has had extensive use in literature (KUMBHAKAR, 2000; PIRES & GARCIA, 2012 and BRAGAGNOLO & BARROS, 2015).

Although the BIC allows the comparison of models when they are not nested, as the case of some pairs of specifications in Table 2.4, this method provides weak evidence of the best specification when the difference in BIC values between models is 2 or smaller (Raftery, 1995). This observation is important in our case because it applies to the comparison of the Cobb-Douglas and the Cobb-Douglas without Technical Progress. As an alternative, one could use the likelihood ratio test when these models are nested; however, it was preferable to work with the Cobb-Douglas with Technical Progress specifications since estimated parameters are very similar, and the time specification is statistically significant.

In addition to the functional form, the type of stochastic frontier model is also important. The literature provides alternative models and some of them can lead to biased results in specific situations, making it difficult to know *a priori* which model would be most satisfactory (Greene, 2005 and Coelli et al., 2005). Therefore, we compare the predictions of the BC 92 model results with those from other models in this paper.

These other models include Greene's True Fixed Effects (TFE) and True Random Effects (TRE) models. These models have previously been compared with other specifications in literature (Greene, 2005). In this analysis, these are estimated for an exponentially distributed inefficiency term and using the ordinary least squares (OLS), which provide unbiased estimates. The Cobb-Douglas functional form is used for this comparison. The results are summarized in Table 2.5.

Table 2.5: Results for different models

Estimator		BC 92	Greene TFE	Greene TRE	OLS
Frontier	*t*	-0.035	-0.034	-0.051	-0.055
		(-2.43)*	(13,863.12)**	(4.68)**	(4.01)**
	lnk	0.563	0.646	0.579	0.565
		(9.59)**	(78,733.11)**	(9.70)**	(10.80)**
	lnl	0.078	0.143	0.076	0.059
		(2.16)*	(24,027.96)**	(2.08)*	-1.58
	lng	0.373	0.452	0.355	0.399
		(6.62)**	(55,639.22)**	(5.93)**	(7.68)**
	_cons	3.071		3.187	2.868
		(13.80)**		(14.40)**	(13.57)**
Sigma	_cons	19.148			
Gamma	_cons	0.998			
Mu	_cons	-164.015			
		-0.08			
Sigma_u	_cons		0.146	0.139	
			(13.08)**	(6.70)**	
Sigma_v	_cons		0.000	0.106	
			(0.02)	(6.92)**	
Eta	_cons	-0.275			
		(2.41)*			
Theta	_cons			0.093	
				(4.53)**	
N		193	171	193	193
R^2					0.92

* $p<0.05$; ** $p<0.01$
Source: Author's analysis.

The results in Table 2.5 suggest that the frontier function coefficient estimates for the Battese and Coelli 1992 model are very similar to those from the other models that were also estimated. This is an evidence that BC 92 is a good model in this case. In all cases, the input elasticity estimates are positive. For capital, the elasticity value is around 0.57 for all models except the Greene TFE, where the elasticity estimates are higher (0.65 in the case of capital).The elasticity for land input is between 0.36 and 0.40 for all models except the Greene TFE, where it is estimated to be 0.45. Labor is the least productive with an elasticity estimate value of 0.14 for the Greene TFE, and lower values (from 0.06 to 0.08) for all other models.

In Tables 2.6 and 2.7, we examine the correlation among inefficiency estimates obtained from the three stochastic frontier models and a non-parametric data envelopment analysis (DEA) frontier.

Table 2.6: Correlation between predicted efficiency

	DEA	BC 92	Greene TFE	Greene TRE
DEA	1			
Battese and Coelli	0.584165069	1		
Greene TFE	0.543608808	0.934425712	1	
Greene TRE	0.681341991	0.5931824	0.545645965	1

Source: Author's analysis

Table 2.7: Correlation between predicted efficiency means by mills

	DEA	BC 92	Greene TFE	Greene TRE
DEA	1			
Battese and Coelli	0.692246879	1		
Greene TFE	0.699734544	0.978964305	1	
Greene TRE	0.696002907	0.891939173	0.842022879	1

Source: Author's analysis

The results in Tables 2.6 and 2.7 show a positive and significant relation between each pair of predictions. The correlations are especially higher among the stochastic frontier models, with the BC 92 and Greene TFE models generating efficiency estimates that are almost perfectly correlated. There is higher correlation between the BC 92 and Greene TRE models (0.89) than between the two Greene models (0.84). All stochastic frontier models have similar correlation values with respect to the DEA results (about 0.70).

The lower correlation between DEA and SFA model efficiency estimates is not surprising, given the different nature of the models. The DEA attributes all deviation from the frontier to inefficiency and is the approach that is likely to identify a larger number of observations as (almost) fully efficient. Still, the relationship between the efficiency estimates is strong and the BC 92 estimates are a good predictor of the DEA results, as used in the Tobit[7] regression results of DEA estimates on BC 92.

[7] A Tobit model for DEA efficiency against BC92 efficiency had as estimated parameters 1.291 for the slope, -0.397 for the intercept, and 0.131 for the sigma parameter, where all of them were significant at 1%.

The results presented above (in Tables 2.5 to 2.7) provide a clear evidence that the BC 92 model is adequate for investigating inefficiency in our data set, being this model used for the following TFP decomposition analysis.

2.3.1 TFP decomposition

As previously discussed, TFP can be decomposed into four components, representing (the first being technical progress (*TP*). However, the TP component can vary depending on how the time effect is modeled, such that two different approaches are compared: i) treating time as a trend and ii) treating time with dummies. Table 2.8 shows the results of these two specifications.

Table 2.8: Stochastic Frontier with time trend and time dummies

		Time trend	Time dummies
Frontier	*t*	-0.035	-
		(2.43)*	
	lnk	0.563	0.552
		(9.59)**	(9.89)**
	lnl	0.078	0.064
		(2.16)*	(-1.90)
	lng	0.373	0.39
		(6.62)**	(7.12)**
	_cons	3.071	3.04
		(13.80)**	(13.95)**
Sigma	_cons	19.148	1.950
Gamma	_cons	0.998	0.940
Mu	_cons	-164.015	-2.268
		-0.08	-0.14
Dummy	2011		0.078
			(2.58)**
	2012		-0.153
			(4.30)**
	2013		-0.021
			-0.5
	2015		-0.158
			-0.74
Eta	_cons	-0.275	-0.266
		(2.41)*	(2.20)*
N		193	193
RTS		1.014	1.007
test *RTS* = 1			
$chi^2(1)$		0.35	0.11
Prob > chi^2		0.552	0.745

* $p<0.05$; ** $p<0.01$
Source: Author's analysis

According to Table 2.8, it is possible to verify that results for the estimate input parameters are almost the same in both specifications. Capital has the highest elasticity, followed by land. And there is no statistical evidence that the returns to scale are different from 1 in either models. However, the dummy variable version shows that the effect of time on output has not smoothed with coefficient values changing between years, although the effect has been monotonic, i.e. all same signs except for the base period (2011). In both models, inefficiency accounts for more than 90% of the random variation, as shown by the gamma value estimates.

In both specifications, the RTS are very close to one, as shown by table 2.8, and it cannot be statistically discarded that RTS is equal to one. This means that, if all inputs are doubled, the output will be doubled as well. However, if RTS was not considered being equal to one, by the construction, the change in the *PS* would be zero.

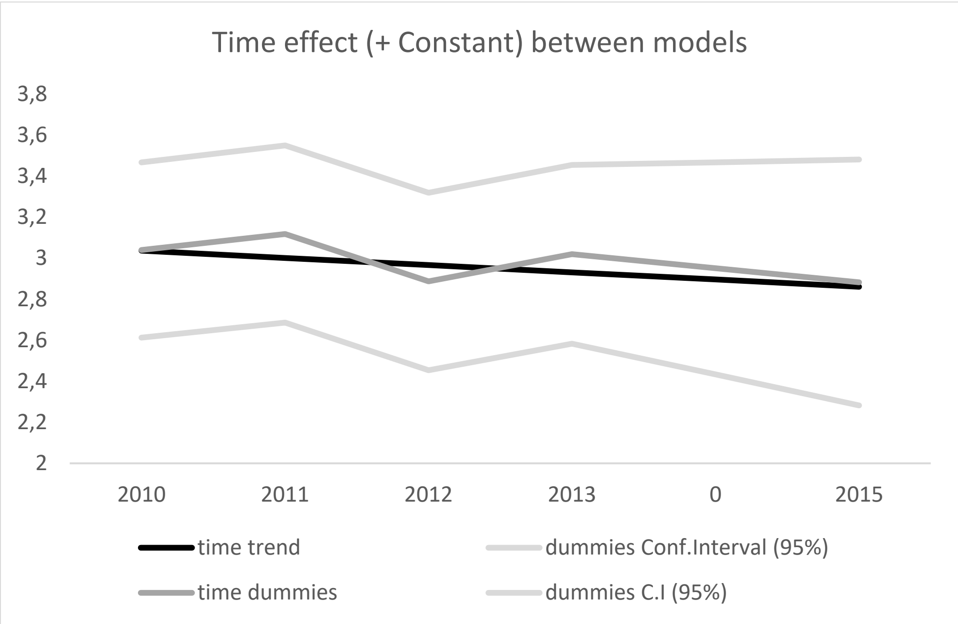

Figure 2.2: Time specification comparison.
Source: Author's analysis

Although the results in Figure 2.2 do not show a significant difference between the two treatments of the time variable, they do lead to different estimates of the technical progress (*TP*) in TFP, as shown in Table 2.9 (Further details on these are in Appendix 4).

Table 2.9 TFP growth and decomposition

Time Variation	Observ.	Change in TFP									
		time dummies					time trend				
		TP	TE	PS	AE	TFP	TP	TE	PS	AE	TFP
2010-2011	40	0.078	-0.024	0.000	-0.012	0.043	-0.035	-0.021	0.001	-0.014	-0.070
2011-2012	34	-0.231	-0.030	0.001	-0.074	-0.333	-0.035	-0.028	0.001	-0.076	-0.138
2012-2013	31	0.132	-0.028	0.000	-0.029	0.075	-0.035	-0.026	0.001	-0.025	-0.086
2013-2015	1	-0.137	-0.049	0.002	0.042	-0.141	-0.070	-0.036	0.004	0.029	-0.074

Source: Author's analysis

Since the main propose of this paper is more general than the specific effect for each mill, the results are shown as averages. More detailed estimates are provided in Appendix 6 and 7. The results in Table 2.9 are in terms of variations, for this information is necessary for each mill in two specific periods. However, since the data is unbalanced, this statistic was not possible for all mills, and because of this the number of observations is also included.

The results in Table 2.9 and Appendix 4 make the distinction between the two models quite clear. For the time trend model, the TFP variations are negative for the whole period. In turn, for the model with time dummies, the technical progress of São Paulo sugar mills had positive and negative results, following a decreasing tendency, and the variation of 2011-2012 was the strongest in the analysis. The positive variation of 2012-2013, however, was not enough to reach the level from the beginning of the analysis. Even though there is an estimate for 2015, and a TFP decrease in 2013-2015, their analyses cannot be considered strong enough, for this variation is not statistically different from zero, and the main reason for this is the very small sample in 2015.

Positive and negative variations in TFP in the time dummies model are due to the *TP* component, which in this model is stronger than the sum of the three others, whereas this same component is always negative and not as representative in the time trend model. The other components have similar results in both models, *TE* and *AE* being negative most of the time, *AE* being positive in 2013-2015, however, the small sample for this period does not allow us to draw any conclusions. The *PS* is always positive, but this last one has very low contribution to the TFP, given their comparative low values in face of other components.

TP analysis indicates that even if the same amount of inputs is used for all years, the results in terms of output throughout time tends to decrease. Even though the time dummies specification indicates that for some years the result could be a little better than the immediately preceding year, the trend is decreasing. This component is modeled to vary in time but not between mills in the same year in the time dummies model, and it is the same for all years and mills in the time trend model. This component represents technical improvement in the industry.

According to Table 2.9 and Appendix 4, *TE* is decreasing for both specifications in all time variations, which was expected, since the variable η, as can be seen in table 2.8, is negative and more distant from zero in the time dummies specification, and in the time trend specification is closer to zero. Moreover, the more negative η is, the more intense will be the decrease in technical efficiency. In other words, the mills, regardless of the specification used, are becoming less technically efficient over time, during the period in this analysis.

A possible explanation for the decrease of these components, TP and TE, is that during the crisis, investments became scarcer, potentially leading to a situation where depreciation is higher than the investment required to replenish both capital and sugarcane in the field, making it less productive. This situation in fact occurred according to Neves and Trombin (2014).

The PS component of the TFP combines information from the Stochastic Frontier models, normalized as shares of factors in production, in Table 2.10, with input growth rate, where the averages are in tables 2.2 and 2.3 and the mill's coefficients are in Appendix 6 and 7. The *PS* results are positive in both models for all periods, but with very little contribution to the TFP due to an RTS very close to one. This component can only be negative with input reduction, in which case capital or land reduction would lead to a decrease in *PS*, given their high shares in production, as shown in Table 2.10, however, these components increased over time in average.

Table 2.10, Shares of factors in production

	Normalized share of factors in production	
	time trend	time dummies
λ_K	0.555	0.549
λ_L	0.077	0.064
λ_G	0.368	0.388

Source: Author's analysis

The results presented in Table 2.10, suggest that capital is the input with the greatest impact on production, followed by land, then labor; and this order is the same in both specifications. These results are derived from the results in Table 2.8.

The AE component is negative in almost the entire period analyzed, being positive only in the 2013-2015 period, but the true effect for this period is uncertain due to the small sample. The *AE* contribution for TFP variation is at times higher and others lower than the *TE* contribution, and is almost always lower than TP contribution, being higher only in 2011-2012 in the time trend model. These results contribute to the decrease of the TFP throughout the period analyzed.

This component, AE, represents gain or loss in mill productivity due to the amount of input variation, considering the relative cost-benefit of these inputs for that specific mill. A verified result for this component in this analysis is that usually; $\lambda_K > S_k$; $\lambda_L < S_L$ and $\lambda_G < S_G$. This means that an increase in capital would usually have a positive effect in this index while an increase in labor and / or land would decrease the *AE*. Through this analysis, a reduction in *AE* would be expected during a crisis, since, according to Neves and Trombin (2014), an increase of capital became difficult due to financial difficulties and low investment levels.

Although, in average, we have a reduction in *AE*, some mills experienced positive or at least non-negative results, what can be explained by their strategies, judgement of the scenario and others individual conditions of the mills. Another issue is that the negative results for *AE* reported in table 2.9 are not statistically different from zero, what could indicate that even though the scenario is not favorable, some mills apparently try to do not reduce in a high scale their *AE*.

2.4 Conclusion

By the analyses of the stochastic frontier model, capital, followed by land and then labor, is the input with higher production elasticity, meaning that a change, *coeteris paribus*, impacts the production more than a similar change in the other outputs. This result shows the importance of the capital for this activity, and the consequences of this result become evident when there are changes in the production scale, and in this case especially, changes in allocative efficiency are analyzed.

The results of this analysis show a decreasing trend in technical progress and a decreasing trend in the technical efficiency for São Paulo's sugarcane mills. This means that the overall productivity change, with the input given, was negative for this time period.

The change in the production to scale component was, on average, positive, but close to zero, which happens because of the practically constant return to scale. However, changes in the allocative efficiency were negative. Net changes in TFP components that incorporate the change in inputs were negative, showing that during the crisis resource allocation became more inefficient, what could have occurred, as previously discussed, due to sunk costs.

With the combination of these components, the change in TFP was negative, the greatest decrease having been during 2011-2012, and this happened because of an intense decrease in allocative efficiency.

The results show that the mills in São Paulo state, on average, became less efficient throughout the crisis, which makes sense given the scenario is not favorable for the sector, and long-term investments in capital could not be carried out, due to an uncertain scenario regarding future prices and financial problems. It is worth noting that many mills went bankrupt in the period analyzed.

The results in this paper are supported by Neves and Trombin (2014) sector's analyses, where a list of problems that could reduce efficiency is presented. Among these problems are; difficulties in obtaining new loans, which could improve the capital used; reduced supply of skilled workers for industrial, agriculture and management activities; lack of cane field renewal, or performing this in an unfavorable manner; rise of maintenance costs; and idle capacity.

Even though this was not tested, there is no evidence contrary to the fact that the financial crisis in the sector was responsible for TFP decrease, since the results show that sugar and ethanol production in São Paulo, Brazil is capital intensive. Given the nature of capital in sugar cane mills, this variable could not change dramatically in the short run, these variations being part of long run strategies, which should negatively affect allocative efficiency, as shown in the results.

The negative effect of time as a trend, such as in variable η, could be partially explained by capital depreciation, since the capital proxy in this paper does not provide information about its quality over time. Another evidence for the negative effect of time can be noticed by table 2.9, where the specification without time trend or time dummies has the smallest value for η.

The results and their analysis suggest that growth in sugar mills' TFP could occur if the investment in this sector increases. These investments may increase if the real prices expected for the long term of sugar and ethanol increase, which would increase the profit and help mills in paying their debts and possibly increase their investments.

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3. ASYMMETRIC PRICE TRANSMISSION IN THE REFINED SUGAR MARKET OF SÃO PAULO

Abstract

This work presents an analysis of the price relations and transmission patterns between producers and retail markets for refined sugar at the State of Sao Paulo, considering aspects such as direction, magnitude and speed of price transmissions. The empirical analysis used monthly averages of prices for the period from May 2003 to February 2015, and the results suggest that the transmission of shocks is bidirectional. Formal tests suggest that the hypothesis of symmetry in price transmission both in the short and long-run from retail to producers cannot be rejected. Therefore, positive or negative exogenous shocks of refined sugar at the retail impact producer's prices in a same magnitude. From an alternative viewpoint, tests have confirmed negative asymmetry in the transmission of changes from producers to retail prices. In fact a reduction in producer prices has stronger impact in reducing retail prices compared to the reaction to an increase in retail prices in response to a positive shock on producer prices, which can be evaluated as positive for final consumers.

Keywords: Refined sugar; Prices; Asymmetric transmission; Market of Sao Paulo

3.1 Introduction:

Concerns about how price transmission occurs between different market levels are relevant for players involved in production management, marketing, and for policy makers. With regard to production and marketing, such information can help, for example, in the efficient planning of operations such as inventory loading, freight contract timing, among other logistic and production decisions. For policy makers, it provides information of price dynamics in response to an idiosyncratic shock, as well as short-term inflation determinants with direct consequences on monetary and fiscal policies (Tripathi e Goyal; 2011).

In this paper, we use some econometric tests to identify the occurrence of asymmetric price transmission (APT) within the refined sugar chain in the state of São Paulo (SP), the greatest consumer market of this product in Brazil. To analyze the occurrence of APT between, for instance, the producer's price and retail price, we analyze how a shock in the producer's price affect the retail price and vice-versa (Meyer e Cramon-Taubadel; 2004). An assessment like this has been done mainly focusing agro-industrial markets (Goodwin and Holt, 1999; Weldesenbet, 2013; Silva Neto and Parré, 2012; Mattos, 2010; Capps and Sherwell, 2007) and the fuel market (Canêdo-Pinheiro, 2012; Goodwin, 2006; Wlazlowski et al, 2012). An explanation to study the prices' behavior in this particular market can be justified, on one hand, by their significant importance in both the household expenditure and in Brazilian inflation indexes as the IPCA. On the other hand, the sectors responsible for supplying these products are, generally, determinants for a significant portion of a country's income, particularly in the case of developing countries.

A basic motivation for this analysis is empirical observation over the accumulated variation of producer prices that differs from that captured in retail prices over a little more than a decade - from December 2003 to December 2014 -, suggesting the possibility of APT in the producer to consumer prices direction. Throughout this period the accumulated variation of the producer’s price was 97%, equivalent to an increase of R$0.74 per kilogram, based on the “*Centro de Estudos Avançados em Economia Aplicada*” (CEPEA) price index. The retail data from the “*Instituto de Economia Agricola*” (IEA) shows that the accumulated variation, in the same period, was slightly higher in absolute value, R$ 0.77 per kilogram, but lower in percentage terms, where it was 71%. These values suggest that a formal test could be relevant to verify the occurrence of APT between these two market levels over the period analyzed. Additionally, Rodrigues and Moraes (2007) found that the refined sugar market has a concentrative character due to entry barriers, mainly due to considerable sunk costs in relation to market size. These authors argue, however, that despite high concentration rates, refined sugar producers have found difficulties to exploit this relative market power with consumers. One possible explanation is that direct competition with large-scale crystal sugar produced in Brazil would result in high price elasticity of demand, in a way that an increase in refined sugar price would result in a more than proportional reduction in consumption, reducing revenue and creating opportunities for an expansion of crystal sugar consumption (Rodrigues and Moraes, 2007).

Besides this market’s importance and the fact that refined sugar is among those with the highest value added, there is a lack of studies focusing this market segment in Brazil, i.e. focusing on APT analysis and their possible causes.

Since the 1990s, the Brazilian government instated the sugar and ethanol sector’s deregulation, forcing the sector to develop self-management mechanisms. With this change, several adjustments became evident in the market and their products, fuel ethanol and sugar. This event motivated an extensive literature on the ethanol fuel Market (Barros, Bacchi and Burnquist; 2002, Alves and Bueno; 2003, Pontes; 2009, Serigati and Perosa; 2010, Gomez; 2010, Costa and Guilhoto; 2011, Farina et al; 2010, Freitas and Kaneko; 2011, Cardoso and Bittencourt; 2012, Santos; 2013). Despite the number of studies on fuel ethanol, literature on refined sugar is still scarce, which justifies this analysis.

This paper presents an overview of the refined sugar market, providing a base for a performance investigation of the marketing chain, from an efficiency analysis in the transmission of market signals to the prices. Following, a description of the concept of asymmetry in product and service transmission is presented to evaluate market behavior. The methodology used is explained in item 4, followed by the presentation and discussion of results, finalizing with the conclusions.

3.2 The refined sugar market in the state of São Paulo.

One way to illustrate the relative importance of refined sugar for the sugar-ethanol industry of São Paulo state is by comparing its numbers with others from the sugar-ethanol sector. Moreover, there are peculiarities in the relations of economic agents who are, directly or indirectly, involved in the refined sugar market, who must be observed in order to comprehend the price formation at different market levels. These characteristics provide useful information to design market strategies and to design efficient policies to improve competition and the good performance of the sugar-alcohol industry.

In Brazil and specifically in the state of São Paulo, the sugar market is relatively complex, given the diversity in their supply chain and their product targeting. At first, there are at least eight different sugar types produced in Brazil, and this situation affects São Paulo, to which belongs the biggest market share in the country sugar production. These different types of sugar correspond to; crystal sugar, classified crystal sugar, extra-fine-crystal sugar, crystal sugar mesh 30, granulated crystal sugar, amorphous crystal sugar, liquid sugar, inverted sugar, and raw sugar, which is classified into two categories; very high purity - VHP and very very high purity – VVHP (Usina Guarani).

The amorphous refined sugar is this study's objective, it is produced via crystal sugar purification, being composed by irregular shaped fine grains, with excellent whiteness and extremely hydroscopic, which easily blends in drinks and other preparations. It is highly used for direct human consumption and can be an ingredient in a large number of recipes, like desserts and bread rolls. The total volume produced represents a relatively small share of all types of sugars produced in São Paulo state and Brazil as well. Table 3.1 shows that the refined sugar production in São Paulo varies between 40 to 30% of the total, considering the mean in the period from 2010/11 to 2014/15.

Table 3.1 – Comparison between total sugar production and refined sugar production in kg in São Paulo and the proportional share of refined sugar, in the crop years from 2010/11 to 2014/15

Crop year	Total Sugar SP (1)	Amorphous Refined Sugar SP (2)	Amorphous Refined Sugar in the Total (2/1) (%)
2010/2011	23.506.910,0	9.356.906,0	39,80
2011/2012	21.112.970,0	8.060.623,0	38,18
2012/2013	23.371.199,0	7.816.481,0	33,44
2013/2014	24.104.056,0	7.325.313,0	30,39
2014/2015	2.1939.468,0	6.773.082,0	30,87

Source: UNICA data.

Apart from the relatively small share of total sugar production, it is notworthy that production variation has been negative. The greatest decrease happened in 2011/12 with the low sugarcane quality due excess raining that affected the produced sugar's quality. The accumulated decrease throughout the four-year crop period in the analysis totaled 31% as shown on Figure 3.1.

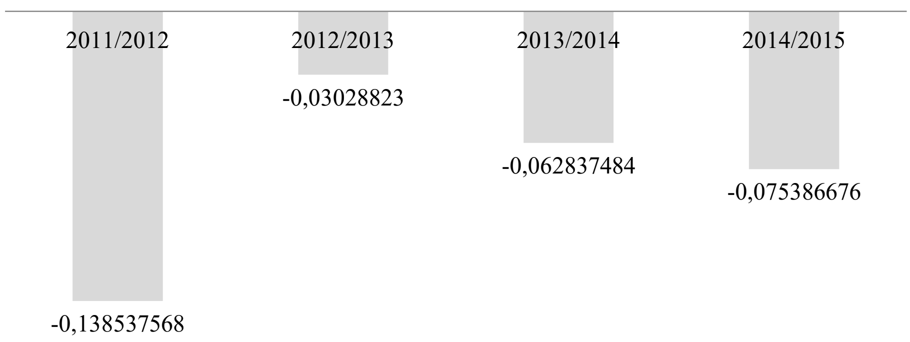

Figure 3.1 - Variation rate in refined sugar production in SP

Source: UNICADATA.

With the sector's consolidation process, the number of producers also decreased in the last decades, as highlighted by Rodrigues and Moraes (2007). In addition, the production of refined sugar, also called white sugar, was selected for empirical analysis by providing a suitable context for a market performance test with the characteristics of this commodity's vertical price transmission from producer to retail. This type of sugar is the consumer's favorite for direct consumption in the SP market, and other states of southeast and south Brazil as well.

Before the 1990s, government intervention in the Brazilian sugar-ethanol sector was relevant to explain the relation between competition through price and the market structure (Rodrigues and Moraes 2007). Between 1969 and 1974, refined sugar prices had a falling trend. In turn, an intensification of the market structure concentration became evident. According to Rodrigues (2005), in 1970s the industry concentration ratio – CR4 was 86%, and in 1974 it increased to 95%. Between 1975 and 1986, refined sugar prices experienced successive increases. During this period, besides the market structure becoming more concentrated, it suffered slight fragmentation, mainly due to the entry of new mills (which used to belong to Copersucar) in isolate competition in the refined sugar market. From 1986 to 1999, the prices had a reduction, leading the sector to slowly restructure itself. Sector deregulation stimulated some mills to include product differentiation as a goal in self-management. With intensified competition in the 2010s, the companies took advantage of the product's good prices and made efforts to increase their market share.

Another relevant aspect in this period was the competition boost in the retail market (supermarkets), despite intensified concentration in the supermarket sector, when large groups with high negotiation power were opening new stores, certainly affecting product price levels (Barros and Claro 2013 and DIEESE 2013).

In addition to sugar type diversification, sugar and ethanol industrial units began to invest in differentiated logistics as an instrument to increase competitiveness. Studies focusing on the sugar market in this period indicated that the main strategies adopted by sugar mills involved changes in business processes and operational activities (production and logistics), improving storage agility, transport and delivery of the product (Bianchini, 2006). These changes involved initiatives such as association for commercialization (consolidated with the creation of Crystalsev), company mergers and acquisitions, market diversification, just-in-time deliveries of sugar, and mills operating as trading companies (Bianchini, 2006). Rodrigues and Moraes (2007) emphasized the importance of identifying the evolution of market structure and competition level that developed throughout this process. The study indicated that the market structure of the sugar refining industry in Brazil suffered from the effect of state regulation through price and trade control.

Another important factor concerns the sector's pricing mechanism. Being a product also traded in the international market, it is expected that its market will be influenced by the price of refined sugar traded in the London Stock Exchange, as well as by the values of sugar marketed in the international market of New York and its respective premium of polarization. Thus, it is believed that the sugar price formed in the foreign market - whether raw or white -

should influence price formation in the domestic market. In addition, the supermarket sector identified by Rodrigues and Moraes (2007) as being highly concentrated, can exert power with refined sugar producers. The analysis associating price level and market structure allows us to conclude that, despite the State's regulation of the product, the market structure was strongly related to price levels, demonstrating a positive relation between price level and market concentration.

3.3 Theoretical reference for Asymmetric price transmission.

The literature about this topic has several contributions for empirical analysis. Meyer and von Cramon-Taubel (2004) and Peltzman (2000) stand out for their theoretical approach, giving us a bottom line to present the concepts of the asymmetric price transmission. Meyer and von Cramon-Taubadel (2004) presented a broad research discussing the nature and plausible reasons why asymmetric price transmission arises. According to Peltzman (2000), consumers notice this asymmetry by the way how costs are incorporated in the price of final goods in several markets. This perception can be noticed in the petrol market, for instance, where there is an intense consumption frequency and an unusual price transparency in other market levels (Perdiguero-Garcia; 2010). Consumers usually blame a non-competitive market and a possible coalition as the main cause of asymmetric price transmission, however, Borenstein Cameron and Gilbert 1997 apud Perdiguero-Garcia; 2010, show a set of reasons where asymmetry can occur in a competitive market. Peltzman (2000) highlights that studies focusing in petrol (Karrenbrock 1991; Borenstein, Cameron and Gilbert 1997), as well as several studies for agricultural commodities (Karrenbrock 1991), concluded that retail prices respond faster to price increase than to a decrease of input prices.

Therefore, it is important to resort to formal tests to demonstrate the existence and categorize which type of asymmetry is happening. In the refined sugar case, after these analyses it is possible to design policies or change strategies to improve market performance. This is the objective of this paper.

Goodwin (2006) highlights that the vertical relation among prices is frequently used as an important index for structure-conduct-performance in the markets analyzed, or to exercise market power more directly. The four main reasons associated to market failure and hence to vertical asymmetric price transmission are: market concentration and market power abuse, government interference, high inflation scenario, adjustment and menu costs, inventory management, and price strategies (Bakucs, Falkowski and Ferto, 2013). When more than one of these conditions occurs in the market, it is expected to reflect some asymmetry. However, there is no evidence of an empirically tested causality with which one could explain the asymmetric price transmission's origin.

The basis of the price theory assumes that consumers and suppliers have direct interaction leading to a balance, which corresponds to the intersection between supply and demand slopes. Hardly ever the producer-received price is the same of consumer-paid prices (Tomek and Robinson, 1972), this difference being called marketing margin, a useful concept to highlight what must be taken into account to analyze the price relation among different market levels. These differences could arise from three sources; value-added, storage, and transport (Barros 2012). Several analyses in vertical asymmetric price transmission try to answer questions such as: Is the marketing margin too high? Why is this margin not homogenous among the goods? Do margin values change over time? Is there any association between margin value and market structure? As answers based on the marketing theory were presented for these questions, the asymmetry in the transmission of prices came to dominate the analysis of the behavior of prices and margin.

For the analysis proposed, it is useful to classify the different asymmetric price transmission types and causes (Meyer and Cramon-Taubadel; 2004). Thus, the possible causes of asymmetric price transmission, as well as a description of the econometric proceedings and their results are shown in this paper.

Figures 3.2 and 3.3 illustrate the main types of asymmetry, which helps to understand this concept. For this work is used the convention proposed by Peltzman (2000) that the asymmetry can be both positive and negative. Assuming two distinct market levels which show the prices $P^{in}$and P^{out}, where P^{out} is due to changes in P^{in}. If P^{out} reacts more intensely to an increase in P^{in} than to a decrease in this variable by the same magnitude, assuming that the P^{out} reaction is always in the same direction as the P^{in}variation, the asymmetry is interpreted as "positive", as shown in Figure 3.2. Analogously, "negative" asymmetry denotes a situation in which the P^{out} reaction is more intense given a negative price change in P^{in}, considering a positive change in the same variable, as shown in Figure 3.3.

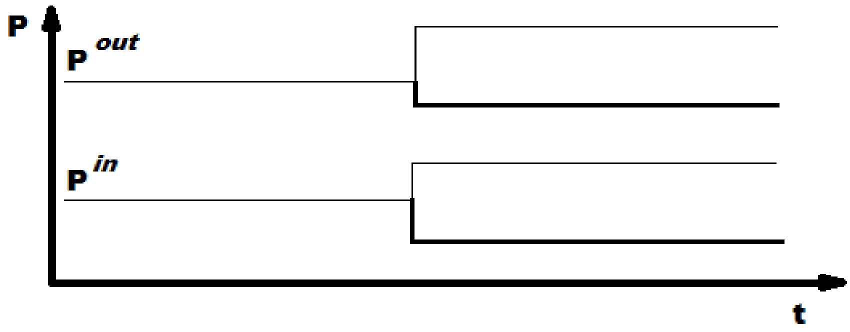

Figure 3.2 Positive Asymmetric Price transmission

Source: Author's own elaboration based on Meyer and von Cramon-Taubadel (2004)

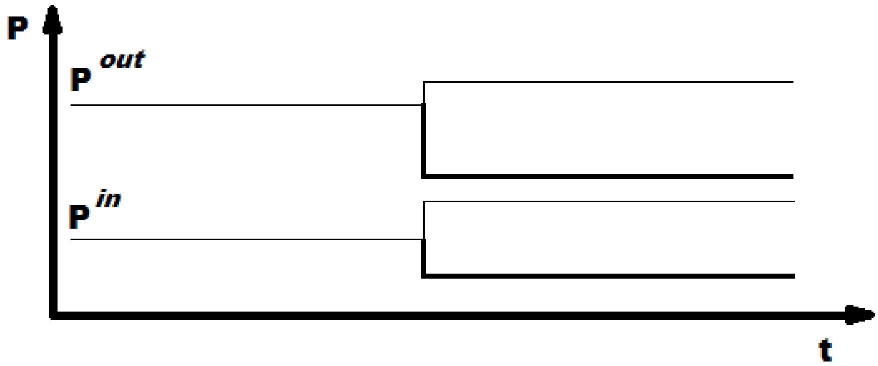

Figure 3.3 Negative Asymmetric Price transmission

Source: Author's own elaboration based on Meyer and von Cramon-Taubadel (2004)

3.4 Methodology and Data

3.4.1 Error Correction Model

For the empirical analysis, an error correction model (ECM) basis is used to obtain the price transmission between two refined sugar market levels (producer and retail). This procedure requires the price series to be cointegrated, and, in this case, the ECM is preferred instead of the procedure described by Houck (1977). Therefore, before estimating an ECM, it is necessary to test for cointegration and then it is useful to perform a Granger causality test, in order to predict the causality direction. Once the condition of cointegration is satisfied, a model proposed by Von-Cramon-Taubadel and Loy (1999), with the modification adopted by Canêdo-Pinheiro (2012), is implemented as in equation 3.1, where the change in retail prices is an endogenous variable:

$$\Delta p_{r_t} = \alpha + \sum_{J=0}^{J^+} \beta_j^+ \Delta p_f^+{}_{t-j} + \sum_{J=0}^{J^-} \beta_j^- \Delta p_f^-{}_{t-j} + \sum_{k=1}^{K^+} \gamma_j^+ \Delta p_r^+{}_{t-j} + \sum_{k=1}^{K} \gamma_j^- \Delta p_r^-{}_{t-j} + \theta^+ ETC_{t-1}^+ + \theta^- ETC_{t-1}^- + \varepsilon_t, \tag{3.1}$$

where Δp_r is the retail price variation, Δp_f is the variation on the producer's price, ETC is the error correction term, ε is a random error, the subscript t represents time and the superscript $(+)$ and $(-)$ indicate whether the variation has positive (otherwise they assume a zero value), or negative values (otherwise, equals zero), respectively. The ETC was obtained from an auxiliary regression, with their predicted residuals, i.e. $ETC_t = p_{r_t} - \delta - \lambda p_{f_t}$, representing a long-term relation between prices. In a model where price transmission occurs in the direction from retail to producers, one should only substitute Δp_r for Δp_f and vice versa. From equation (3.1) it is possible to implement the following asymmetry tests (Pinheiro, 2012 and Weldesenbet, 2013): (i) contemporaneous impact asymmetry (COIA), if $\beta_0^+ \neq \beta_0^-$; (ii) distributed lag effect asymmetry (DLEA)[8], if $\beta_j^+ \neq \beta_j^-$ for a j $\in [0, \max(J^+, J^-)]$; (iii) cumulated impact asymmetry (CUIA) until lag J, if $\Sigma_{j=J}^{J^+} \neq \Sigma_{j=J}^{J^-}$, where $J \in [0, \min(J^+, J^-)]$;(iv) total cumulated impact asymmetry (TCIA) if $\Sigma_{j=J}^{J^+} \neq \Sigma_{j=J}^{J^-}$,; (v) equilibrium adjustment path asymmetry (EAPA) if $\theta^+ \neq \theta^-$, i.e. if the convergence "speed" depends on whether the retail price is above $(ETC_{t-1} \geq 0)$ or under $(ETC_{t-1} < 0)$ the long-term price balance. All these tests can be performed as an F test. Note that COIA, DLEA, CUIA and TCIA test for a short-run asymmetric behavior, comparing the positive and negative impact of p_f on p_r in a given period; while EAPA tests for long-term asymmetry.

3.4.2 Data

This study used monthly price series of amorphous refined sugar paid to the producer and paid by the retail consumer. Both series start in May of 2003[9] and end in February of 2015. For the value paid to the producer, a monthly average was calculated from the daily indicator series of the Center for Advanced Studies in Applied Economics (CEPEA) for refined sugar prices. As for the retail price, it was obtained from the Institute of Agricultural

[8] In this case, $J^+ \neq J^-$ implies in DLE, but the opposite is not true (Pinheiro 2012).

[9] The series beginning being in May of 2003 is due the beginning of CEPEA refined sugar price index.

Economics (IEA) database, where the monthly price series of white sugar packaged in 1kg sacks is published, which corresponds to the amorphous refined sugar sold in the retail market. Both price series for 1kg of refined amorphous sugar are presented in Figure 3.4. It is demonstrated that prices had a significant rise in the period from April 2008 to April 2010. After this period, even if there were price changes, it is noted that these are maintained at higher levels and that there is an increase in the marketing margin[10], a fact that changes from 2013 onwards when prices decrease. However, the drop in prices is more intense in retail than in the producer's level.

Apparently, the price series shown in Figure 3.4 does not have fixed averages over time, and they also seem to share the same trajectory over time, that is, they have the same stochastic tendency, with cointegration between the series. There is also greater variation in prices in the period from the end of 2008 to 2010.

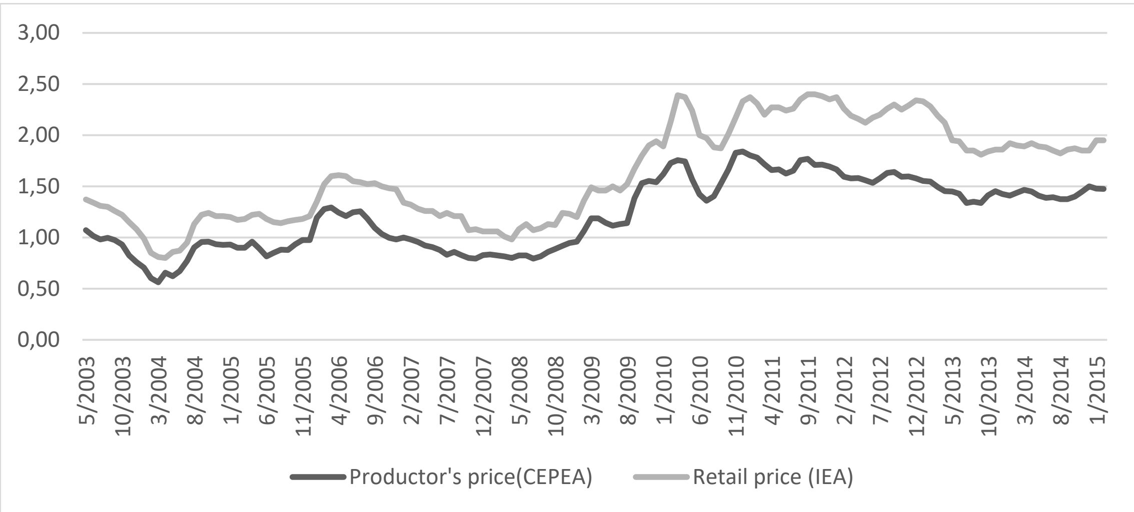

Figure 3.4 Refined sugar prices in Brazilian Real at producer and retail price levels.
Source: CEPEA and IEA databases

[10] In this case, the market margin is the difference between the retail and producers prices.

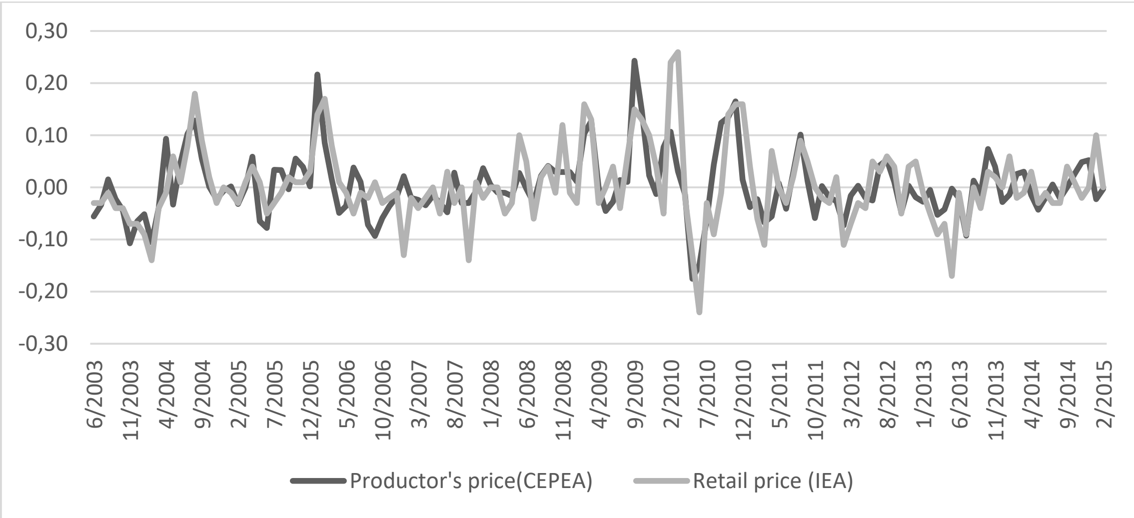

Figure 3.5 Refined sugar prices in Brazilian Real in first difference at producer and retail price level.
Source: CEPEA and IEA databases.

In Figure 3.5 it is possible to visually infer that both price series became stationary after the first difference.

3.5 Results and Discussion

3.5.1 Unit root test

Within a cointegration context, the first step is to make sure that the series is non-stationary; to do this it is usual to perform some unit root tests in the time series. Therefore, three unit root tests were used in this analysis; the Dickey-Fuller Generalized Least Squares (DF-GLS), Phillips Perron (PP) and Kwiatkowski, Phillps, Schmidt, and Shin (KPSS). The null-hypothesis of DF-GLS and PP being the existence of one unit root[11], that means the time series in non-stationary; on the other hand, the KPSS test has the stationarity of the time series as the null-hypothesis. The KPSS test is often used in literature as a way to confirm the DF-GLS and PP results. The results of these tests can be found in Table 3.2. The results indicate that both price series are non-stationary in level, but became stationary after the first differentiation, an indication that they are first order integrated.

[11] We did not test for more than one unit root, because the time series looks stationary after the first difference, for that reason tests like Dickey-Pantula were not performed.

Table 3.2. Unit root tests' results.

	Variables in level						Variables in first difference (Δ)					
	No constant and trend	No constant		Constant and trend		No constant and trend		No constant		Constant and trend	
Producer Price											
PP	0.113	-1.221		-2.239		-6.361	***	-6.333	***	-6.297	***
DF - GLS	-	-1.255		-2.035		-		-5.415	***	-6.639	***
KPSS	-	1.042	***	0.130	*	-		0.093		0.092	
Retail price											
PP	0.138	-1.212		-2.048		-7.091	***	-7.073	***	-7.044	***
DF - GLS	-	-1.260		-2.157		-		-6.831	***	-7.194	***
KPSS	-	0.984	***	0.134	*	-		0.093		0.093	

Note: ***1% of statistical significance, **5% of statistical significance e *10% of statistical significance.
Source: Authors analysis.

3.5.2 Cointegration

With both time series being first order integrated, we can test if both of them share the same long-run stochastic trend, in other words, if they are cointegrated. Thus, we performed a Johansen test, which is sensitive to the number of lags used. For this reason, it was tested using vector autoregression models (VAR), which would be the best order of lag using the Akaike, Bayesian and Hannan-Quinn Information Criteria (Weldesenbet 2013). We also chose to use the third equation of the Johansen test, and the results of the tests are in Table 3.3. Both the trace and maximum eigenvalue tests indicate the presence of a cointegration vector between prices. This leads to the conclusion that the variables are cointegrated, which enables the use of error correction models.

Table 3.3. Johansen test for cointegration results

Test	Hypothesis No. of vectors	Trace statistics	p - value
Trace			
	None	27.994	0.000
	At maximum 1	1.965	0.161
Max Eigenvalue			
	None	26.029	0.001
	1	1.964	0.161

Source: Authors results and p value by MacKinnon-Haug-Michelis (1999).

3.5.3 Granger causality

Granger causality is a temporal causality, which indicates whether the price and lagged price at one level influence the price at another level, at the present time. The condition required to verify the Granger causality tests is the stationarity of the series tested, i.e. with integrated variables in the first order. In analyses applying the vector autoregression (VAR) model, Granger causality is the only type of causality to be tested. As for the context of cointegration with an error-correction vector model (VECM), causality among variables is also associated with error correction, representing long-term causality, and the Granger causality test is associated to short-term causality.

Another important aspect about Granger causality is that it is sensitive to the number of lags used. For this reason, tests were performed for different numbers of lags, in addition to the optimal number of lags found previously for the Johansen procedure. The results of the Granger causality tests are shown in Table 3.4.

Table 3.4. Granger causality test results.

Null Hypothesis	Chi²	Probability	Number of lags
Producer price does not	13.042	0.002 ***	2
Granger-cause	12.851	0.012 **	4
Retail price	15.152	0.019 **	6
	15.142	0.056 *	8
Retail price does not	8.333	0.002 ***	2
Granger-cause	8.422	0.077 *	4
Producer price	12.604	0.050 **	6
	13.587	0.093 *	8

Fonte: Author's own calculations
Note: Null hypothesis rejection at ***1%, **5% and *10% of statistical significance.

The Granger causality results indicate that there is a bi-causality between prices at producer and retail levels, suggesting that both respond to changes in each other's prices. Thus, an exogenous change in producer prices will reflect in retail prices, just as an exogenous shock in retail prices will affect prices at the producer level. These results are important for this research by indicating which equations we should estimate. In the case of bi-causality, we chose to estimate two equations, one considering retail prices as an endogenous variable and the other considering producer prices as a variable being explained by the lagged prices themselves and the lagged prices of consumer prices.

3.5.4 Error-correction model

According to the previous item's test results, we estimate two error correction equations; one referring to the retail price response to a shock occurred in producer prices; another refers to the response of price shocks at the retail level with repercussions on producer prices. These expressions are estimated separately and each presents the best number of lags according to selection criteria (Akaike and Bayesians), and a total of 625 models were tested for each equation. Another relevant point to note is that, generally, when considering a chain that starts at the producer level and ends at the retail level, the asymmetry in price transmission deals with downstream shocks causing upstream impacts. However, Barros (2012) argues that an upward change in prices may impact downstream prices. This possibility has been confirmed for refined amorphous sugar prices and will be treated by the second equation shown in this section.

For asymmetric price transmission analysis of shocks occurring in producer prices, here adopting the notation (p_f) impacting retail prices (p_r), an error correction model was estimated according to Equation 3.1, choosing the optimal number of lags based on the information criteria cited. This model and the results of its estimation are shown in Table 3.5 and are consistent with the expected, negative and significant error correction terms. Some price estimates with lags have negative values, which would mean that the above (below) equilibrium prices are expected to decrease (increase) (WELDESENBET 2013). Another point to be highlighted is that the estimates of producer price parameters and the error correction term represent a decrease in absolute values higher than the values of the respective parameters referring to an increase.

Considering the estimates shown in Table 3.5, the asymmetry tests proposed in the methodology section, using the respective acronyms adopted, are performed and shown in Table 3.6. It should be noted that, since the model presents only one producer price lag, both in the case of positive and negative variations, the tests for CUIA and TCIA will be the same. The results shown in Table 3.6 indicate that the null hypothesis of long-term and short-term price transmission symmetry should be rejected at 5% and 1% of statistical significance, respectively, except for the short-term test of contemporary asymmetry that did not reject the hypothesis of symmetry. Results suggest there is asymmetry in the transmission of refined sugar prices of the retail producer and that this asymmetry is negative, that is, decreases in producer prices reduce retail prices more intensely than increases in producer prices raise prices in retail.

Table 3.5. Error correction model (Δp_r)

Variable Δp_r	Estimated coefficient	T statistic	
constant	0.016	1.87	*
$\Delta p_{f\ t}^{+}$	0.300	1.24	
$\Delta p_{f\ t-1}^{+}$	-0.707	-2.93	***
$\Delta p_{f\ t}^{-}$	0.741	4.80	***
$\Delta p_{f\ t-1}^{-}$	0.225	1.21	
$\Delta p_{r\ t-1}^{+}$	0.330	3.34	***
$\Delta p_{r\ t-2}^{+}$	-0.345	-3.68	***
$\Delta p_{r\ t-1}^{-}$	0.004	0.03	
ETC_{t-1}^{+}	-0.205	-2.48	**
ETC_{t-1}^{1}	-0.540	-6.76	***
R^2	0.637		
DW	1.951		
AIC	-448.775		
BIC	-419.430		

Cointegration regression

	Estimated coefficient	T statistic	
constant	-0.021	-0.67	
p_f	1.349	55.51	***

Note: ***1%, **5% and *10% of statistical significance
source: Author's analysis.

Table 3.6 Asymmetric price transmission from p_f to p_r results.

Test acronym	F statistic	P - value	
COIA	2.31	0.1307	
DLEA (1 lag)	9.95	0.0020	***
CUIA = TCIA	13.87	0.0003	***
EAPA	6.36	0.0129	**

Note: ***1%, **5% and *10% of statistical significance
source: Author's analysis.

The second equation estimated is associated to the producer price response, due to changes in retail prices, following the same procedure as the previous equation, being estimated based on equation 3.1, but with the change from p_r to p_f and vice versa, being described in Table 3.7.

Table 3.7. Error correction model (Δp_f)

Variable Δp_f	Estimated coefficient	T statistic	
Constant	0.003	0.46	
$\Delta p_{r\ t}^{+}$	0.664	6.27	***
$\Delta p_{r\ t-1}^{+}$	-0.081	-0.82	
$\Delta p_{r\ t}^{-}$	0.420	3.51	***
$\Delta p_{r\ t-1}^{-}$	0.064	0.52	
$\Delta p_{f\ t-1}^{+}$	0.260	1.82	*
$\Delta p_{f\ t-1}^{-}$	0.316	1.80	*
ETC_{t-1}^{+}	-0.356	-2.96	***
ETC_{t-1}^{1}	-0.185	-1.51	
R²	0.488		
DW	1.917		
AIC	-462.535		
BIC	-436.060		

Cointegration regression

	Estimated coefficient	T statistic	
Constante	0.068	3.12	***
p_r	0.709	55.44	***

Note: ***1%, **5% and *10% of statistical significance
source: Author's analysis.

The asymmetry tests performed based on the results shown in Table 3.7 are shown in Table 3.8. These do not reject the hypothesis that there is symmetry in the transmission of prices in both short and long terms, i.e. it is not statistically rejected that positive or negative exogenous shocks in the prices of refined sugar at retail impacting producer prices have the same magnitude.

Table 3.8 Asymmetric price transmission from p_r to p_f results.

Test acronym	F statistic	P - value
COIA	1.96	0.1639
DLEA (1 lag)	0.68	0.4125
CUIA = TCIA	0.16	0.6858
EAPA	0.79	0.3770

Note: ***1%, **5% and *10% of statistical significance
source: Author's analysis.

The results for the lags of both positive and negative retail price changes were not statistically significant, but the same retail price changes were statistically significant for the contemporary period, i.e. for period t.

3.6 Conclusions

In the market of refined amorphous sugar in the state of São Paulo, at both market levels studied - producer and retail -, the changes in their prices are transmitted to other market levels. However, these transmissions occur in different ways with regard to the asymmetry of price transmission, and one cannot reject the hypothesis that price transmission is symmetrical when retail prices are subject to a shock which is passed on to the producer. Conversely, the symmetry hypothesis is rejected when the shock starts at the producer and is passed on to the retailer.

The hypothesis that the exercise of market power on refined sugar from São Paulo would imply a positive price transmission asymmetry. This leads to the conclusion that there is no evidence that retailers are exercising market power. In fact the results show that changes in producer prices have larger impact on retail prices when these are negative, which seems to be a favorable characteristic for final consumers, since they are not subject to a behavior closer to a monopolist Supermarket. Although this does not mean that the prices paid by final consumers in the retail market are decreasing.

For public policies, the evidence that positive shocks on producer prices will be passed on to consumers less intensely than negative shocks will allow us to consider reductions in taxes levied on producers, both direct and indirect, such as Brazilian tributes IR / CSLL, IPI, ICMS, ISS, PIS and COFINS, would be passed on to the retail level, benefiting final consumers.

As previously highlighted herein and in related literature, the methodology used does not enable to identify the reasons that explain what has actually occurred. However, among the plausible explanations, to be proven by future analyses, are the following: (i) being a product of the Brazilian staple food, refined sugar presents a more inelastic demand than its supply, hence a tax exemption on retail prices may result in a greater drop in prices charged by retailers than those by producers; (ii) the change of habits of Brazilians and campaigns against refined sugar consumption (these explanations are not complementary); (iii) the increase in concentration and competition of retailers over the period of the analysis may have caused a decline refined sugar prices to the consumer; (iv) as a strategy to increase market concentration, it may have occurred the reverse of the expected price behavior when there is abuse of market power, in an alternative to that raised in item (i), i.e. if it would be valid that the demand for refined sugar is not so inelastic as assumed in the argument above. (v) Another possibility is that it has become more elastic over time, given a likely increase in the supply of competing products, such as ground crystal sugar, which has a lower production cost; (vi) an increase in the consumption of foods with higher added value that use other types of sugars in detriment of foods made at home that use refined amorphous sugar, and even the reduction of itsconsumption due to campaigns to reduce consumption of this type of sweetener, such as campaigns for type 2 diabetes prevention.

Thus, suggestions for future research would be to verify the evolution of the price elasticity of demand for refined sugar in Brazil, and especially in south-central regions, where this type of sugar is most consumed, in order to validate possible explanations for price shock behavior.

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APPENDIX

Appendix 1: Correlation between output and inputs pairs.

	TRS	K	L	G
TRS	1			
K	0.991	1		
L	0.981	0.978	1	
G	0.984	0.987	0.966	1

Source: Author's analysis using data from "*Anuário da Cana*" (2010, 2011, 2012, 2013 and 2015) and CONSECANA table to convert sugar and ethanol into TRS

Appendix 2: Regression of Land x Total Milling Cane.

	Total Milling Cane
Land (G)	81.930
	(86.25)**
_cons	10,904.815
	(0.18)
R^2	0.97
N	193

Note: * p<0.05; ** p<0.01

Source: Author's analysis

Appendix 3: Technology Functions Results (part 1/3)

Technology		Translog	Harrod neutral	Solow neutral	"Land" neutral
Frontier	t	0.052	0.051	0.024	-0.245
		-0.24	-0.23	-0.11	-1.24
	lnk	-0.916	-1.492	-0.801	-1.5
		-1	-1.72	-0.88	-1.68
	lnl	0.067	0.284	0.011	0.108
		-0.12	-0.5	-0.02	-0.18
	lng	1.902	2.331	1.857	2.656
		(1.97)*	(2.48)*	-1.9	(2.84)**
	tlnk	0.107		0.138	-0.004
		(2.07)*		(2.93)**	-0.11
	tlnl	0.049	0.08		0.032
		-1.4	(2.50)*		-0.92
	tlng	-0.148	-0.07	-0.137	
		(2.92)**	(2.04)*	(2.72)**	
	t2	0.015	0.011	0.012	0.002
		-0.71	-0.5	-0.57	-0.11
	lnk2	-0.367	-0.408	-0.382	-0.48
		-1.7	-1.86	-1.78	(2.22)*
	lnl2	-0.099	-0.069	-0.117	-0.074
		-1.01	-0.71	-1.19	-0.75
	lng2	-0.626	-0.745	-0.595	-0.782
		(3.11)**	(3.87)**	(2.96)**	(3.99)**
	lnklnl	-0.053	-0.024	0.017	0.123
		-0.16	-0.07	-0.05	-0.35
	lnklng	0.973	1.193	0.913	1.223
		(3.33)**	(4.41)**	(3.15)**	(4.43)**
	lnllng	0.161	0.036	0.156	-0.035
		-0.47	-0.1	-0.46	-0.1
	_cons	2.195	1.914	2.14	1.29
		-1.25	-1.09	-1.2	-0.74
$Sigma^2$	_cons	0.046	0.053	0.045	0.060
Gamma	_cons	0.457	0.499	0.439	0.548
Mu	_cons	-0.01	-0.088	0.021	-0.159
		-0.02	-0.09	-0.05	-0.11
Eta	_cons	-0.263	-0.254	-0.264	-0.257
		(2.07)*	-1.87	(2.15)*	-1.89
N		193	193	193	193
BIC		-23.615	-24.604	-26.935	-20.507

Note: * $p<0.05$; ** $p<0.01$

Source: Author’s analysis

Appendix 3: Technology Functions Results (part 2/3)

Technology		Hicks neutral	"Harrod-land" neutral	"Solow-land" neutral	"Hicks-land" neutral
Frontier	t	-0.008	-0.258	-0.248	-0.04
		-0.04	-1.59	-1.25	-0.73
	lnk	-1.596	-1.479	-1.394	-1.587
		-1.82	-1.7	-1.57	-1.82
	lnl	0.296	0.093	0.069	0.273
		-0.51	-0.16	-0.12	-0.49
	lng	2.501	2.653	2.591	2.528
		(2.62)**	(2.83)**	(2.75)**	(2.70)**
	tlnk			0.023	
				-1.1	
	tlnl		0.029		
			-1.42		
	tlng	-0.003			
		-0.15			
	t2	0.002	0.002	0.001	0.001
		-0.09	-0.1	-0.04	-0.07
	lnk2	-0.467	-0.481	-0.487	-0.472
		(2.12)*	(2.23)*	(2.24)*	(2.17)*
	lnl2	-0.091	-0.075	-0.088	-0.09
		-0.92	-0.76	-0.89	-0.91
	lng2	-0.745	-0.779	-0.753	-0.748
		(3.79)**	(4.01)**	(3.87)**	(3.84)**
	lnklnl	0.152	0.127	0.165	0.158
		-0.43	-0.37	-0.47	-0.45
	lnklng	1.197	1.217	1.172	1.199
		(4.41)**	(4.51)**	(4.32)**	(4.43)**
	lnllng	-0.061	-0.033	-0.032	-0.063
		-0.18	-0.09	-0.09	-0.18
	_cons	1.59	1.278	1.282	1.529
		-0.88	-0.73	-0.71	-0.87
Sigma²	_cons	0.054	0.059	0.056	0.055
Gamma	_cons	0.499	0.545	0.520	0.509
Mu	_cons	-0.078	-0.152	-0.109	-0.092
		-0.08	-0.11	-0.09	-0.09
Eta	_cons	-0.247	-0.257	-0.256	-0.248
		-1.87	-1.89	-1.9	-1.88
N		193	193	193	193
BIC		-23.744	-25.758	-24.932	-28.984

Note: * $p<0.05$; ** $p<0.01$

Source: Author’s analysis

Appendix 3: Technology Functions Results (part 3/3)

Technology		Translog without TP	Cobb-Douglas	Cobb-Douglas without TP
Frontier	t		-0.035	
			(2.43)*	
	lnk	-1.524	0.563	0.574
		-1.67	(9.59)**	(7.75)**
	lnl	0.219	0.078	0.085
		-0.37	(2.16)*	(2.26)*
	lng	2.275	0.373	0.347
		(2.40)*	(6.62)**	(5.06)**
	tlnk			
	tlnl			
	tlng			
	t2			
	lnk2	-0.417		
		(2.01)*		
	lnl2	-0.07		
		-0.69		
	lng2	-0.792		
		(4.19)**		
	lnklnl	-0.026		
		-0.08		
	lnklng	1.223		
		(4.70)**		
	lnllng	0.089		
		-0.27		
	_cons	2.827	3.071	3.118
		-1.75	(13.80)**	(12.90)**
Sigma²	_cons	0.035	19.148	0.12
Gamma	_cons	0.233	0.998	0.770
Mu	_cons	0.291	-164.015	-0.384
		-1.17	-0.08	-0.15
Eta	_cons	-0.177	-0.275	-0.331
		-1.22	(2.41)*	(2.04)*
N		193	193	193
BIC		-36.330	-42.745	-42.386

Note: * $p<0.05$; ** $p<0.01$

Source: Author's analysis

Appendix 4: TFP growth and decomposition statistics

Technical Progress (TP)

Time variation	Technical Progress (TP)			
	time dummies		time trend	
2010-2011	0.078	**	-0.035	*
2011-2012	-0.231	**	-0.035	*
2012-2013	0.132	**	-0.035	*
2013-2015	-0.137		-0.07	*
2013-2014	-0.0685		-0.035	*
2014-2015	-0.0685		-0.035	*

Note: * p<0.05; ** p<0.01

The variations 2013-2014 and 2014-2015 for the time dummies model were estimated using half of the 2013-2015 variation.

Source: Author's analysis

Chance in technical efficiency (TE)

Time variation	Obs.	Change in technical efficiency							
		time dummies				time trend			
		max	min	mean	sd	max	min	mean	sd
2010-2011	40	-0.005	-0.098	-0.024	0.023	-0.005	-0.097	-0.021	0.021
2011-2012	34	-0.006	-0.127	-0.03	0.028	-0.007	-0.128	-0.028	0.028
2012-2013	31	-0.008	-0.08	-0.028	0.019	-0.009	-0.07	-0.026	0.016
2013-2015	1	-0.049	-0.049	-0.049	-	-0.036	-0.036	-0.036	-

Source: Author's analysis

Change in The production scale (PS)

Time variation	Obs.	Change in the production scale							
		time dummies				time trend			
		max	min	mean	sd	max	min	mean	sd
2010-2011	40	0.008	-0.003	0.001	0.002	0.004	-0.002	0.0003	0.001
2011-2012	34	0.014	-0.001	0.001	0.003	0.008	-0.001	0.001	0.002
2012-2013	31	0.007	-0.002	0.001	0.002	0.003	-0.001	0.0003	0.001
2013-2015	1	0.004	0.004	0.004	-	0.002	0.002	0.002	-

Source: Author's analysis

Change in the allocative efficiency (AE)

Time variation	Obs.	Change in the allocative efficiency							
		time dummies				time trend			
		max	min	mean	sd	max	min	mean	sd
2010-2011	40	0.185	-0.250	-0.014	0.090	0.183	-0.234	-0.012	0.087
2011-2012	34	0.150	-0.925	-0.076	0.208	0.152	-0.877	-0.074	0.204
2012-2013	31	0.154	-0.386	-0.025	0.125	0.151	-0.405	-0.029	0.128
2013-2015	1	0.029	0.029	0.029	-	0.042	0.042	0.042	-

Source: Author's analysis

Change in TPF

Time variation	Obs.	Change in TFP							
		time dummies				time trend			
		max	min	mean	sd	max	min	mean	sd
2010-2011	40	0.132	-0.306	-0.070	0.092	0.245	-0.193	0.043	0.090
2011-2012	34	0.098	-0.969	-0.138	0.213	-0.099	-1.121	-0.334	0.208
2012-2013	31	0.105	-0.447	-0.086	0.128	0.263	-0.290	0.075	0.132
2013-2015	1	-0.074	-0.074	-0.074	-	-0.141	-0.141	-0.141	-

Source: Author's analysis

Appendix 5: Factor's Growth Correlation

Growth correlation (all years)

	gowthK	*gowthL*	*gowthG*
gowthK	1		
gowthL	0.002476	1	
gowthG	0.067656	-0.07579	1

Source: Author's analysis

Growth correlation (2010-2011)

	gowthK	*gowthL*	*gowthG*
gowthK	1		
gowthL	0.100272	1	
gowthG	0.262395	0.100023	1

Source: Author's analysis

Growth correlation (2011-2012)

	gowthK	*gowthL*	*gowthG*
gowthK	1		
gowthL	-0.07403	1	
gowthG	-0.09051	-0.14284	1

Source: Author's analysis

Growth correlation (2012-2013)

	gowthK	*gowthL*	*gowthG*
gowthK	1		
gowthL	0.011267	1	
gowthG	0.386489	0.226707	1

Source: Author's analysis

Appendix 6: Complete Results for the Time Trend model (part 1/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
1	2011	-0.120	0.000	-0.155	-0.004	-0.025	-0.035	-0.021	0.000	0.032	0.064
1	2012	0.139	0.000	0.031	0.034	-0.079	-0.035	-0.028	0.000	-0.016	0.153
4	2011	0.275	0.200	0.048	0.236	-0.031	-0.035	-0.009	0.003	0.011	-0.178
4	2012	-0.258	0.000	-0.042	0.073	-0.064	-0.035	-0.012	0.000	-0.017	-0.225
4	2013	0.036	-0.100	0.013	-0.057	-0.086	-0.035	-0.016	-0.001	-0.035	0.266
5	2011	-0.036	0.000	-0.116	0.298	-0.085	-0.035	-0.022	0.001	-0.030	-0.132
5	2012	-0.192	-0.080	-0.138	0.229	-0.122	-0.035	-0.028	0.000	-0.059	-0.082
5	2013	-0.144	0.000	0.125	-0.301	-0.079	-0.035	-0.037	-0.001	-0.005	0.111
6	2011	-0.139	0.062	0.000	-0.169	-0.088	-0.035	-0.097	0.000	0.044	0.056
6	2012	-0.107	0.000	-0.094	2.759	-0.434	-0.035	-0.127	0.014	-0.285	-2.339
7	2011	-0.019	0.429	0.123	0.272	0.079	-0.035	-0.016	0.005	0.125	-0.921
7	2015	0.205	0.167	-0.298	0.544	-0.074	-0.070	-0.036	0.004	0.029	-0.134
8	2011	0.104	-0.030	-0.344	0.400	-0.206	-0.035	-0.010	0.001	-0.162	0.284
9	2011	0.172	-0.038	0.271	0.272	-0.195	-0.035	-0.011	0.001	-0.150	-0.137
10	2013	-0.069	0.000	0.409	0.026	-0.218	-0.035	-0.062	0.001	-0.121	-0.287
13	2011	0.104	0.000	0.000	0.036	-0.069	-0.035	-0.015	0.000	-0.019	0.137
13	2012	-0.183	0.000	-0.222	0.295	-0.108	-0.035	-0.020	0.001	-0.054	-0.148
13	2013	-0.029	0.000	0.107	-0.089	-0.068	-0.035	-0.027	0.000	-0.005	0.020
14	2012	-0.273	0.000	0.137	0.004	-0.134	-0.035	-0.053	0.000	-0.046	-0.280
14	2013	0.373	0.000	0.030	0.243	-0.158	-0.035	-0.070	0.001	-0.054	0.257
15	2013	0.351	0.000	1.620	0.000	-0.198	-0.035	-0.029	0.002	-0.136	-1.070
16	2012	-0.102	0.000	0.016	0.067	-0.082	-0.035	-0.026	0.000	-0.022	-0.104
17	2011	0.588	0.000	-0.444	0.037	-0.015	-0.035	-0.021	0.000	0.041	1.011
18	2011	-0.077	0.000	0.002	0.238	-0.123	-0.035	-0.014	0.001	-0.076	-0.193
18	2012	-0.084	0.226	-0.306	-0.035	0.098	-0.035	-0.018	0.001	0.150	-0.068
18	2013	0.101	-0.121	0.061	-0.005	-0.122	-0.035	-0.024	-0.001	-0.063	0.289
19	2011	0.133	0.000	0.008	0.061	-0.068	-0.035	-0.014	0.000	-0.020	0.131
19	2012	-0.190	0.069	0.012	-0.016	-0.016	-0.035	-0.018	0.000	0.036	-0.239
19	2013	0.037	0.000	0.139	-0.060	-0.076	-0.035	-0.024	0.000	-0.017	0.034
20	2011	0.004	0.000	0.163	0.237	-0.153	-0.035	-0.018	0.001	-0.101	-0.243
20	2012	-0.285	0.000	0.077	-0.160	-0.040	-0.035	-0.024	-0.001	0.020	-0.162
20	2013	0.045	0.000	0.191	-0.076	-0.112	-0.035	-0.031	0.000	-0.045	0.041
21	2013	0.189	0.000	0.292	0.199	-0.207	-0.035	-0.056	0.001	-0.118	-0.095
22	2011	-0.031	0.000	0.000	0.026	-0.059	-0.035	-0.015	0.000	-0.009	0.001
23	2011	0.000	0.000	0.000	0.000	-0.049	-0.035	-0.014	0.000	0.000	0.049
25	2012	-0.152	0.000	-0.107	-0.128	0.015	-0.035	-0.009	-0.001	0.059	0.069
25	2013	0.194	0.000	0.000	-0.043	-0.034	-0.035	-0.011	0.000	0.012	0.271
26	2013	0.092	0.190	0.088	-0.029	0.019	-0.035	-0.021	0.001	0.073	-0.176
27	2011	-0.360	0.000	0.000	-0.383	0.024	-0.035	-0.016	-0.002	0.077	0.000
27	2012	0.141	0.000	-0.121	0.314	-0.121	-0.035	-0.021	0.001	-0.066	0.068
27	2013	-0.048	0.000	0.046	-0.475	0.034	-0.035	-0.028	-0.002	0.099	0.348
28	2011	0.018	-0.126	-0.131	-0.070	-0.072	-0.035	-0.024	-0.001	-0.012	0.418
30	2012	-0.099	0.000	0.530	0.031	-0.182	-0.035	-0.035	0.001	-0.112	-0.480
30	2013	-0.118	0.000	-0.658	0.025	-0.028	-0.035	-0.046	-0.001	0.053	0.542
31	2011	0.345	0.000	-0.017	0.187	-0.104	-0.035	-0.013	0.001	-0.057	0.278
31	2012	-0.145	0.167	0.115	-0.013	0.015	-0.035	-0.018	0.001	0.066	-0.429
31	2013	0.128	0.000	-0.041	0.028	-0.057	-0.035	-0.023	0.000	0.001	0.198
33	2011	0.112	0.000	0.000	0.101	-0.094	-0.035	-0.026	0.001	-0.034	0.105

Appendix 6: Complete Results for the Time Trend model (part 2/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
33	2012	-0.671	-0.062	-0.109	0.063	-0.080	-0.035	-0.034	0.000	-0.011	-0.484
33	2013	1.976	0.202	0.220	0.051	-0.031	-0.035	-0.044	0.002	0.047	1.533
34	2011	0.166	-0.026	0.000	0.240	-0.116	-0.035	-0.005	0.001	-0.077	0.069
34	2012	-0.282	-0.150	-0.344	0.052	-0.093	-0.035	-0.007	-0.001	-0.050	0.253
34	2013	0.248	0.176	0.212	0.184	-0.050	-0.035	-0.009	0.002	-0.008	-0.275
35	2011	0.211	-0.071	-0.239	0.344	-0.164	-0.035	-0.008	0.001	-0.123	0.342
35	2012	-0.248	0.154	0.000	-0.192	0.096	-0.035	-0.010	0.000	0.140	-0.306
35	2013	0.152	0.027	0.529	0.140	-0.189	-0.035	-0.013	0.001	-0.142	-0.354
37	2012	-0.163	-0.125	0.175	0.135	-0.197	-0.035	-0.024	0.000	-0.138	-0.151
45	2011	0.206	0.000	0.000	0.167	-0.084	-0.035	-0.023	0.001	-0.027	0.123
46	2011	-0.019	0.000	0.000	-0.177	0.025	-0.035	-0.011	-0.001	0.073	0.133
46	2012	-0.304	0.000	0.000	0.000	-0.050	-0.035	-0.015	0.000	0.000	-0.254
49	2011	-0.435	0.000	0.000	-0.245	-0.073	-0.035	-0.080	-0.001	0.044	-0.118
50	2013	-0.135	0.000	1.945	-0.039	-0.430	-0.035	-0.019	0.002	-0.378	-1.611
51	2012	-0.313	0.000	-0.113	-0.165	-0.004	-0.035	-0.039	-0.001	0.071	-0.031
52	2012	-0.422	0.000	0.182	0.357	-0.211	-0.035	-0.047	0.002	-0.131	-0.751
53	2011	0.710	0.000	0.131	0.874	-0.306	-0.035	-0.026	0.005	-0.250	0.011
54	2011	-0.045	-0.118	-0.187	0.311	-0.170	-0.035	-0.012	0.000	-0.123	0.119
54	2012	-0.096	0.222	0.003	0.352	-0.055	-0.035	-0.016	0.003	-0.008	-0.617
54	2013	0.347	0.636	0.348	0.297	0.105	-0.035	-0.021	0.007	0.154	-1.039
55	2013	0.010	0.226	-0.005	0.052	0.047	-0.035	-0.016	0.002	0.096	-0.310
57	2011	0.091	0.044	-0.016	0.125	-0.066	-0.035	-0.019	0.001	-0.014	0.005
57	2012	-0.214	0.006	0.000	0.048	-0.071	-0.035	-0.024	0.000	-0.011	-0.196
58	2011	-0.006	0.000	-0.689	0.068	-0.064	-0.035	-0.016	0.000	-0.013	0.680
58	2012	-0.024	-0.167	2.352	-0.011	-0.560	-0.035	-0.021	0.001	-0.506	-1.638
59	2011	0.295	-0.034	0.041	-0.037	-0.062	-0.035	-0.012	0.000	-0.015	0.388
59	2012	-0.220	0.000	-0.012	0.318	-0.134	-0.035	-0.016	0.002	-0.085	-0.392
59	2013	0.059	0.143	0.543	0.054	-0.180	-0.035	-0.021	0.002	-0.126	-0.502
60	2011	0.304	0.000	0.014	0.261	-0.120	-0.035	-0.011	0.001	-0.075	0.149
60	2012	-0.176	-0.051	-0.102	0.074	-0.077	-0.035	-0.014	0.000	-0.028	-0.020
60	2013	0.073	0.054	0.405	0.068	-0.153	-0.035	-0.019	0.001	-0.101	-0.301
61	2013	0.053	0.063	-0.287	-0.023	0.014	-0.035	-0.018	0.000	0.067	0.287
62	2011	0.269	0.000	0.119	0.128	-0.104	-0.035	-0.010	0.001	-0.060	0.126
62	2012	-0.251	0.000	-0.092	-0.238	0.032	-0.035	-0.014	-0.001	0.082	0.046
62	2013	0.061	0.080	0.075	0.001	-0.036	-0.035	-0.018	0.001	0.016	-0.059
63	2011	0.242	0.000	-0.007	-0.154	0.013	-0.035	-0.006	-0.001	0.055	0.389
63	2012	-0.238	0.000	0.091	0.084	-0.085	-0.035	-0.008	0.001	-0.042	-0.328
63	2013	0.104	0.000	0.063	-0.008	-0.053	-0.035	-0.011	0.000	-0.008	0.102
65	2011	0.147	0.029	-0.586	0.174	-0.068	-0.035	-0.014	0.000	-0.020	0.599
65	2012	-0.072	0.028	-0.188	-0.032	-0.020	-0.035	-0.018	0.000	0.033	0.141
66	2013	0.127	0.050	-0.078	-0.143	0.039	-0.035	-0.010	0.000	0.085	0.260
67	2012	0.026	0.088	3.223	-0.108	-0.478	-0.035	-0.007	0.003	-0.439	-2.698
67	2013	0.079	0.000	-0.171	-0.318	0.085	-0.035	-0.009	-0.002	0.132	0.483
68	2011	0.281	0.080	0.000	-0.188	0.034	-0.035	-0.016	0.000	0.085	0.355
69	2011	0.478	0.000	0.267	0.275	-0.205	-0.035	-0.042	0.002	-0.130	0.141
69	2012	-0.376	0.300	0.156	-0.122	0.060	-0.035	-0.055	0.002	0.148	-0.770
70	2011	0.099	-0.037	-0.444	-0.428	0.132	-0.035	-0.015	-0.003	0.185	0.876
70	2012	-0.124	0.000	-0.058	2.358	-0.968	-0.035	-0.020	0.012	-0.925	-1.455

Appendix 6: Complete Results for the Time Trend model (part 3/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
72	2011	0.002	0.031	0.004	0.126	-0.074	-0.035	-0.008	0.001	-0.033	-0.085
72	2012	-0.110	-0.030	0.414	-0.013	-0.112	-0.035	-0.010	0.000	-0.067	-0.369
72	2013	-0.031	0.000	0.000	-0.188	0.010	-0.035	-0.013	-0.001	0.059	0.146
74	2011	0.118	0.677	-0.139	0.537	0.128	-0.035	-0.014	0.008	0.169	-1.085
75	2011	0.080	0.000	0.183	-0.446	0.082	-0.035	-0.007	-0.002	0.126	0.262
76	2013	0.056	0.000	0.117	-0.429	-0.008	-0.035	-0.036	-0.002	0.065	0.376
77	2011	-0.226	-0.059	-0.462	-0.072	-0.016	-0.035	-0.020	-0.001	0.040	0.382
79	2013	0.081	0.000	1.008	0.278	-0.447	-0.035	-0.028	0.002	-0.386	-0.758
80	2011	-0.045	0.000	0.017	0.255	-0.182	-0.035	-0.097	0.001	-0.051	-0.134
80	2012	-0.079	0.000	-0.099	1.262	-0.425	-0.035	-0.128	0.006	-0.268	-0.817

Source: Author's analysis

Appendix 7: Complete Results for the Time Dummies model (part 1/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
1	2011	-0.120	0.000	-0.155	-0.004	0.091	0.078	-0.021	0.000	0.034	-0.051
1	2012	0.139	0.000	0.031	0.034	-0.274	-0.231	-0.027	0.000	-0.016	0.348
4	2011	0.275	0.200	0.048	0.236	0.084	0.078	-0.009	0.001	0.013	-0.293
4	2012	-0.258	0.000	-0.042	0.073	-0.258	-0.231	-0.012	0.000	-0.015	-0.031
4	2013	0.036	-0.100	0.013	-0.057	0.081	0.132	-0.015	-0.001	-0.035	0.099
5	2011	-0.036	0.000	-0.116	0.298	0.030	0.078	-0.027	0.001	-0.023	-0.247
5	2012	-0.192	-0.080	-0.138	0.229	-0.317	-0.231	-0.035	0.000	-0.052	0.113
5	2013	-0.144	0.000	0.125	-0.301	0.074	0.132	-0.045	-0.001	-0.013	-0.041
6	2011	-0.139	0.062	0.000	-0.169	0.020	0.078	-0.098	0.000	0.040	-0.053
6	2012	-0.107	0.000	-0.094	2.759	-0.580	-0.231	-0.127	0.007	-0.229	-2.192
7	2011	-0.019	0.429	0.123	0.272	0.185	0.078	-0.022	0.002	0.126	-1.027
7	2015	0.205	0.167	-0.298	0.544	-0.141	-0.137	-0.049	0.002	0.042	-0.067
8	2011	0.104	-0.030	-0.344	0.400	-0.081	0.078	-0.010	0.001	-0.149	0.159
9	2011	0.172	-0.038	0.271	0.272	-0.081	0.078	-0.012	0.001	-0.148	-0.251
10	2013	-0.069	0.000	0.409	0.026	-0.061	0.132	-0.067	0.000	-0.126	-0.444
13	2011	0.104	0.000	0.000	0.036	0.041	0.078	-0.018	0.000	-0.018	0.026
13	2012	-0.183	0.000	-0.222	0.295	-0.300	-0.231	-0.024	0.001	-0.045	0.044
13	2013	-0.029	0.000	0.107	-0.089	0.092	0.132	-0.031	0.000	-0.009	-0.139
14	2012	-0.273	0.000	0.137	0.004	-0.340	-0.231	-0.061	0.000	-0.048	-0.074
14	2013	0.373	0.000	0.030	0.243	0.003	0.132	-0.080	0.001	-0.050	0.096
15	2013	0.351	0.000	1.620	0.000	-0.057	0.132	-0.032	0.001	-0.158	-1.211
16	2012	-0.102	0.000	0.016	0.067	-0.276	-0.231	-0.025	0.000	-0.021	0.090
17	2011	0.588	0.000	-0.444	0.037	0.100	0.078	-0.025	0.000	0.048	0.895
18	2011	-0.077	0.000	0.002	0.238	-0.008	0.078	-0.016	0.001	-0.071	-0.308
18	2012	-0.084	0.226	-0.306	-0.035	-0.099	-0.231	-0.021	0.001	0.152	0.129
18	2013	0.101	-0.121	0.061	-0.005	0.042	0.132	-0.027	0.000	-0.063	0.125
19	2011	0.133	0.000	0.008	0.061	0.045	0.078	-0.014	0.000	-0.019	0.018
19	2012	-0.190	0.069	0.012	-0.016	-0.214	-0.231	-0.019	0.000	0.035	-0.041
19	2013	0.037	0.000	0.139	-0.060	0.087	0.132	-0.025	0.000	-0.020	-0.129
20	2011	0.004	0.000	0.163	0.237	-0.041	0.078	-0.021	0.001	-0.099	-0.355
20	2012	-0.285	0.000	0.077	-0.160	-0.243	-0.231	-0.027	0.000	0.016	0.041
20	2013	0.045	0.000	0.191	-0.076	0.047	0.132	-0.036	0.000	-0.049	-0.118
21	2013	0.189	0.000	0.292	0.199	-0.044	0.132	-0.059	0.001	-0.118	-0.259
22	2011	-0.031	0.000	0.000	0.026	0.054	0.078	-0.017	0.000	-0.008	-0.111
23	2011	0.000	0.000	0.000	0.000	0.062	0.078	-0.016	0.000	0.000	-0.062
25	2012	-0.152	0.000	-0.107	-0.128	-0.182	-0.231	-0.008	0.000	0.058	0.265
25	2013	0.194	0.000	0.000	-0.043	0.133	0.132	-0.010	0.000	0.012	0.104
26	2013	0.092	0.190	0.088	-0.029	0.183	0.132	-0.020	0.001	0.070	-0.340
27	2011	-0.360	0.000	0.000	-0.383	0.127	0.078	-0.019	-0.001	0.069	-0.104
27	2012	0.141	0.000	-0.121	0.314	-0.313	-0.231	-0.025	0.001	-0.058	0.260
27	2013	-0.048	0.000	0.046	-0.475	0.188	0.132	-0.032	-0.001	0.089	0.194
28	2011	0.018	-0.126	-0.131	-0.070	0.036	0.078	-0.030	-0.001	-0.011	0.310
30	2012	-0.099	0.000	0.530	0.031	-0.394	-0.231	-0.044	0.000	-0.119	-0.267
30	2013	-0.118	0.000	-0.658	0.025	0.137	0.132	-0.058	0.000	0.063	0.377
31	2011	0.345	0.000	-0.017	0.187	0.011	0.078	-0.015	0.001	-0.053	0.164
31	2012	-0.145	0.167	0.115	-0.013	-0.187	-0.231	-0.020	0.001	0.063	-0.227
31	2013	0.128	0.000	-0.041	0.028	0.108	0.132	-0.026	0.000	0.002	0.033
33	2011	0.112	0.000	0.000	0.101	0.014	0.078	-0.032	0.000	-0.032	-0.003

Appendix 7: Complete Results for the Time Dummies model (part 2/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
33	2012	-0.671	-0.062	-0.109	0.063	-0.281	-0.231	-0.042	0.000	-0.007	-0.282
33	2013	1.976	0.202	0.220	0.051	0.122	0.132	-0.055	0.001	0.044	1.381
34	2011	0.166	-0.026	0.000	0.240	0.002	0.078	-0.005	0.001	-0.072	-0.049
34	2012	-0.282	-0.150	-0.344	0.052	-0.281	-0.231	-0.006	-0.001	-0.043	0.441
34	2013	0.248	0.176	0.212	0.184	0.117	0.132	-0.008	0.001	-0.008	-0.442
35	2011	0.211	-0.071	-0.239	0.344	-0.041	0.078	-0.008	0.001	-0.112	0.219
35	2012	-0.248	0.154	0.000	-0.192	-0.105	-0.231	-0.010	0.000	0.136	-0.105
35	2013	0.152	0.027	0.529	0.140	-0.027	0.132	-0.013	0.001	-0.146	-0.516
37	2012	-0.163	-0.125	0.175	0.135	-0.392	-0.231	-0.024	0.000	-0.137	0.043
45	2011	0.206	0.000	0.000	0.167	0.025	0.078	-0.030	0.000	-0.024	0.014
46	2011	-0.019	0.000	0.000	-0.177	0.136	0.078	-0.011	0.000	0.069	0.022
46	2012	-0.304	0.000	0.000	0.000	-0.245	-0.231	-0.014	0.000	0.000	-0.059
49	2011	-0.435	0.000	0.000	-0.245	0.018	0.078	-0.098	-0.001	0.039	-0.209
50	2013	-0.135	0.000	1.945	-0.039	-0.290	0.132	-0.018	0.001	-0.405	-1.751
51	2012	-0.313	0.000	-0.113	-0.165	-0.202	-0.231	-0.039	-0.001	0.069	0.167
52	2012	-0.422	0.000	0.182	0.357	-0.404	-0.231	-0.048	0.001	-0.126	-0.558
53	2011	0.710	0.000	0.131	0.874	-0.193	0.078	-0.039	0.002	-0.234	-0.102
54	2011	-0.045	-0.118	-0.187	0.311	-0.049	0.078	-0.014	0.000	-0.114	-0.002
54	2012	-0.096	0.222	0.003	0.352	-0.250	-0.231	-0.018	0.002	-0.003	-0.423
54	2013	0.347	0.636	0.348	0.297	0.263	0.132	-0.023	0.003	0.151	-1.198
55	2013	0.010	0.226	-0.005	0.052	0.214	0.132	-0.014	0.001	0.095	-0.477
57	2011	0.091	0.044	-0.016	0.125	0.050	0.078	-0.017	0.001	-0.011	-0.112
57	2012	-0.214	0.006	0.000	0.048	-0.264	-0.231	-0.023	0.000	-0.010	-0.003
58	2011	-0.006	0.000	-0.689	0.068	0.061	0.078	-0.015	0.000	-0.002	0.555
58	2012	-0.024	-0.167	2.352	-0.011	-0.786	-0.231	-0.019	0.000	-0.536	-1.413
59	2011	0.295	-0.034	0.041	-0.037	0.050	0.078	-0.012	0.000	-0.016	0.276
59	2012	-0.220	0.000	-0.012	0.318	-0.325	-0.231	-0.016	0.001	-0.078	-0.202
59	2013	0.059	0.143	0.543	0.054	-0.021	0.132	-0.021	0.001	-0.133	-0.660
60	2011	0.304	0.000	0.014	0.261	-0.003	0.078	-0.011	0.001	-0.070	0.033
60	2012	-0.176	-0.051	-0.102	0.074	-0.270	-0.231	-0.015	0.000	-0.025	0.173
60	2013	0.073	0.054	0.405	0.068	0.009	0.132	-0.019	0.001	-0.105	-0.462
61	2013	0.053	0.063	-0.287	-0.023	0.184	0.132	-0.018	0.000	0.070	0.117
62	2011	0.269	0.000	0.119	0.128	0.009	0.078	-0.010	0.000	-0.059	0.013
62	2012	-0.251	0.000	-0.092	-0.238	-0.167	-0.231	-0.014	-0.001	0.079	0.245
62	2013	0.061	0.080	0.075	0.001	0.129	0.132	-0.018	0.000	0.015	-0.225
63	2011	0.242	0.000	-0.007	-0.154	0.124	0.078	-0.006	0.000	0.052	0.278
63	2012	-0.238	0.000	0.091	0.084	-0.280	-0.231	-0.007	0.000	-0.042	-0.133
63	2013	0.104	0.000	0.063	-0.008	0.114	0.132	-0.010	0.000	-0.009	-0.065
65	2011	0.147	0.029	-0.586	0.174	0.057	0.078	-0.013	0.000	-0.009	0.474
65	2012	-0.072	0.028	-0.188	-0.032	-0.213	-0.231	-0.017	0.000	0.035	0.334
66	2013	0.127	0.050	-0.078	-0.143	0.206	0.132	-0.008	0.000	0.083	0.093
67	2012	0.026	0.088	3.223	-0.108	-0.721	-0.231	-0.006	0.001	-0.485	-2.455
67	2013	0.079	0.000	-0.171	-0.318	0.250	0.132	-0.008	-0.001	0.128	0.318
68	2011	0.281	0.080	0.000	-0.188	0.141	0.078	-0.018	0.000	0.081	0.248
69	2011	0.478	0.000	0.267	0.275	-0.093	0.078	-0.044	0.001	-0.128	0.030
69	2012	-0.376	0.300	0.156	-0.122	-0.147	-0.231	-0.058	0.001	0.141	-0.563
70	2011	0.099	-0.037	-0.444	-0.428	0.245	0.078	-0.015	-0.002	0.183	0.763
70	2012	-0.124	0.000	-0.058	2.358	-1.121	-0.231	-0.019	0.006	-0.877	-1.302

Appendix 7: Complete Results for the Time Dummies model (part 3/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
72	2011	0.002	0.031	0.004	0.126	0.040	0.078	-0.008	0.000	-0.030	-0.199
72	2012	-0.110	-0.030	0.414	-0.013	-0.313	-0.231	-0.010	0.000	-0.073	-0.167
72	2013	-0.031	0.000	0.000	-0.188	0.174	0.132	-0.013	-0.001	0.056	-0.017
74	2011	0.118	0.677	-0.139	0.537	0.244	0.078	-0.015	0.004	0.177	-1.201
75	2011	0.080	0.000	0.183	-0.446	0.184	0.078	-0.008	-0.001	0.115	0.160
76	2013	0.056	0.000	0.117	-0.429	0.149	0.132	-0.037	-0.001	0.055	0.219
77	2011	-0.226	-0.059	-0.462	-0.072	0.098	0.078	-0.025	-0.001	0.045	0.268
79	2013	0.081	0.000	1.008	0.278	-0.290	0.132	-0.030	0.001	-0.394	-0.915
80	2011	-0.045	0.000	0.017	0.255	-0.065	0.078	-0.097	0.001	-0.047	-0.251
80	2012	-0.079	0.000	-0.099	1.262	-0.597	-0.231	-0.127	0.003	-0.242	-0.646

Source: Author's analysis

Appendix 8: Complete Results for the No Time Specification model (part 1/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
1	2011	-0.120	0.000	-0.155	-0.004	-0.001	0.000	-0.031	0.000	0.031	0.040
1	2012	0.139	0.000	0.031	0.034	-0.060	0.000	-0.043	0.000	-0.017	0.134
4	2011	0.275	0.200	0.048	0.236	-0.004	0.000	-0.014	0.001	0.009	-0.205
4	2012	-0.258	0.000	-0.042	0.073	-0.038	0.000	-0.019	0.000	-0.019	-0.251
4	2013	0.036	-0.100	0.013	-0.057	-0.062	0.000	-0.026	0.000	-0.035	0.241
5	2011	-0.036	0.000	-0.116	0.298	-0.070	0.000	-0.033	0.001	-0.038	-0.147
5	2012	-0.192	-0.080	-0.138	0.229	-0.112	0.000	-0.046	0.000	-0.066	-0.092
5	2013	-0.144	0.000	0.125	-0.301	-0.062	0.000	-0.064	-0.001	0.003	0.094
6	2011	-0.139	0.062	0.000	-0.169	-0.063	0.000	-0.112	0.000	0.049	0.030
6	2012	-0.107	0.000	-0.094	2.759	-0.499	0.000	-0.155	0.006	-0.349	-2.274
7	2011	-0.019	0.429	0.123	0.272	0.100	0.000	-0.028	0.002	0.126	-0.942
7	2015	0.205	0.167	-0.298	0.544	-0.058	0.000	-0.076	0.002	0.017	-0.150
8	2011	0.104	-0.030	-0.344	0.400	-0.187	0.000	-0.014	0.001	-0.174	0.265
9	2011	0.172	-0.038	0.271	0.272	-0.170	0.000	-0.015	0.001	-0.155	-0.163
10	2013	-0.069	0.000	0.409	0.026	-0.214	0.000	-0.096	0.000	-0.119	-0.291
13	2011	0.104	0.000	0.000	0.036	-0.045	0.000	-0.025	0.000	-0.020	0.112
13	2012	-0.183	0.000	-0.222	0.295	-0.097	0.000	-0.035	0.001	-0.062	-0.159
13	2013	-0.029	0.000	0.107	-0.089	-0.051	0.000	-0.048	0.000	-0.003	0.004
14	2012	-0.273	0.000	0.137	0.004	-0.122	0.000	-0.076	0.000	-0.045	-0.293
14	2013	0.373	0.000	0.030	0.243	-0.165	0.000	-0.106	0.001	-0.059	0.265
15	2013	0.351	0.000	1.620	0.000	-0.173	0.000	-0.050	0.001	-0.124	-1.095
16	2012	-0.102	0.000	0.016	0.067	-0.064	0.000	-0.041	0.000	-0.023	-0.122
17	2011	0.588	0.000	-0.444	0.037	0.008	0.000	-0.029	0.000	0.037	0.987
18	2011	-0.077	0.000	0.002	0.238	-0.101	0.000	-0.020	0.001	-0.081	-0.216
18	2012	-0.084	0.226	-0.306	-0.035	0.125	0.000	-0.028	0.001	0.152	-0.094
18	2013	0.101	-0.121	0.061	-0.005	-0.103	0.000	-0.039	0.000	-0.064	0.270
19	2011	0.133	0.000	0.008	0.061	-0.042	0.000	-0.021	0.000	-0.021	0.106
19	2012	-0.190	0.069	0.012	-0.016	0.008	0.000	-0.030	0.000	0.038	-0.263
19	2013	0.037	0.000	0.139	-0.060	-0.057	0.000	-0.042	0.000	-0.015	0.014
20	2011	0.004	0.000	0.163	0.237	-0.135	0.000	-0.030	0.001	-0.105	-0.261
20	2012	-0.285	0.000	0.077	-0.160	-0.018	0.000	-0.042	0.000	0.024	-0.184
20	2013	0.045	0.000	0.191	-0.076	-0.100	0.000	-0.058	0.000	-0.042	0.029
21	2013	0.189	0.000	0.292	0.199	-0.208	0.000	-0.089	0.001	-0.120	-0.094
22	2011	-0.031	0.000	0.000	0.026	-0.030	0.000	-0.021	0.000	-0.009	-0.028
23	2011	0.000	0.000	0.000	0.000	-0.020	0.000	-0.020	0.000	0.000	0.020
25	2012	-0.152	0.000	-0.107	-0.128	0.047	0.000	-0.014	0.000	0.061	0.037
25	2013	0.194	0.000	0.000	-0.043	-0.006	0.000	-0.019	0.000	0.013	0.243
26	2013	0.092	0.190	0.088	-0.029	0.041	0.000	-0.037	0.001	0.078	-0.198
27	2011	-0.360	0.000	0.000	-0.383	0.059	0.000	-0.026	-0.001	0.086	-0.036
27	2012	0.141	0.000	-0.121	0.314	-0.109	0.000	-0.036	0.001	-0.074	0.057
27	2013	-0.048	0.000	0.046	-0.475	0.060	0.000	-0.050	-0.001	0.110	0.322
28	2011	0.018	-0.126	-0.131	-0.070	-0.047	0.000	-0.033	-0.001	-0.014	0.393
30	2012	-0.099	0.000	0.530	0.031	-0.164	0.000	-0.055	0.000	-0.109	-0.497
30	2013	-0.118	0.000	-0.658	0.025	-0.029	0.000	-0.077	0.000	0.048	0.543
31	2011	0.345	0.000	-0.017	0.187	-0.081	0.000	-0.021	0.000	-0.061	0.255
31	2012	-0.145	0.167	0.115	-0.013	0.042	0.000	-0.029	0.001	0.070	-0.456
31	2013	0.128	0.000	-0.041	0.028	-0.040	0.000	-0.040	0.000	0.000	0.181
33	2011	0.112	0.000	0.000	0.101	-0.073	0.000	-0.037	0.000	-0.036	0.084

Appendix 8: Complete Results for the No Time Specification model (part 2/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
33	2012	-0.671	-0.062	-0.109	0.063	-0.066	0.000	-0.052	0.000	-0.014	-0.497
33	2013	1.976	0.202	0.220	0.051	-0.021	0.000	-0.073	0.001	0.050	1.524
34	2011	0.166	-0.026	0.000	0.240	-0.090	0.000	-0.008	0.000	-0.083	0.043
34	2012	-0.282	-0.150	-0.344	0.052	-0.068	0.000	-0.011	-0.001	-0.056	0.227
34	2013	0.248	0.176	0.212	0.184	-0.022	0.000	-0.015	0.001	-0.008	-0.303
35	2011	0.211	-0.071	-0.239	0.344	-0.145	0.000	-0.012	0.000	-0.133	0.323
35	2012	-0.248	0.154	0.000	-0.192	0.131	0.000	-0.016	0.000	0.147	-0.341
35	2013	0.152	0.027	0.529	0.140	-0.163	0.000	-0.023	0.001	-0.141	-0.380
37	2012	-0.163	-0.125	0.175	0.135	-0.181	0.000	-0.039	0.000	-0.142	-0.167
45	2011	0.206	0.000	0.000	0.167	-0.065	0.000	-0.034	0.000	-0.031	0.104
46	2011	-0.019	0.000	0.000	-0.177	0.060	0.000	-0.017	0.000	0.077	0.099
46	2012	-0.304	0.000	0.000	0.000	-0.023	0.000	-0.023	0.000	0.000	-0.281
49	2011	-0.435	0.000	0.000	-0.245	-0.056	0.000	-0.105	-0.001	0.049	-0.135
50	2013	-0.135	0.000	1.945	-0.039	-0.396	0.000	-0.034	0.001	-0.362	-1.646
51	2012	-0.313	0.000	-0.113	-0.165	0.015	0.000	-0.058	0.000	0.074	-0.050
52	2012	-0.422	0.000	0.182	0.357	-0.210	0.000	-0.074	0.001	-0.138	-0.752
53	2011	0.710	0.000	0.131	0.874	-0.303	0.000	-0.037	0.002	-0.269	0.008
54	2011	-0.045	-0.118	-0.187	0.311	-0.153	0.000	-0.020	0.000	-0.133	0.103
54	2012	-0.096	0.222	0.003	0.352	-0.039	0.000	-0.028	0.002	-0.013	-0.634
54	2013	0.347	0.636	0.348	0.297	0.124	0.000	-0.039	0.003	0.159	-1.058
55	2013	0.010	0.226	-0.005	0.052	0.073	0.000	-0.026	0.001	0.098	-0.336
57	2011	0.091	0.044	-0.016	0.125	-0.042	0.000	-0.027	0.000	-0.016	-0.019
57	2012	-0.214	0.006	0.000	0.048	-0.050	0.000	-0.037	0.000	-0.012	-0.217
58	2011	-0.006	0.000	-0.689	0.068	-0.042	0.000	-0.022	0.000	-0.020	0.658
58	2012	-0.024	-0.167	2.352	-0.011	-0.521	0.000	-0.031	0.001	-0.490	-1.678
59	2011	0.295	-0.034	0.041	-0.037	-0.034	0.000	-0.020	0.000	-0.014	0.360
59	2012	-0.220	0.000	-0.012	0.318	-0.119	0.000	-0.027	0.001	-0.092	-0.408
59	2013	0.059	0.143	0.543	0.054	-0.158	0.000	-0.038	0.001	-0.121	-0.524
60	2011	0.304	0.000	0.014	0.261	-0.098	0.000	-0.017	0.001	-0.081	0.127
60	2012	-0.176	-0.051	-0.102	0.074	-0.055	0.000	-0.024	0.000	-0.031	-0.042
60	2013	0.073	0.054	0.405	0.068	-0.131	0.000	-0.033	0.001	-0.098	-0.323
61	2013	0.053	0.063	-0.287	-0.023	0.033	0.000	-0.033	0.000	0.066	0.267
62	2011	0.269	0.000	0.119	0.128	-0.079	0.000	-0.017	0.000	-0.062	0.101
62	2012	-0.251	0.000	-0.092	-0.238	0.063	0.000	-0.024	-0.001	0.087	0.016
62	2013	0.061	0.080	0.075	0.001	-0.015	0.000	-0.033	0.000	0.018	-0.080
63	2011	0.242	0.000	-0.007	-0.154	0.049	0.000	-0.009	0.000	0.059	0.353
63	2012	-0.238	0.000	0.091	0.084	-0.056	0.000	-0.013	0.000	-0.043	-0.357
63	2013	0.104	0.000	0.063	-0.008	-0.025	0.000	-0.018	0.000	-0.007	0.074
65	2011	0.147	0.029	-0.586	0.174	-0.047	0.000	-0.019	0.000	-0.028	0.578
65	2012	-0.072	0.028	-0.188	-0.032	0.006	0.000	-0.027	0.000	0.033	0.115
66	2013	0.127	0.050	-0.078	-0.143	0.072	0.000	-0.016	0.000	0.088	0.227
67	2012	0.026	0.088	3.223	-0.108	-0.420	0.000	-0.011	0.002	-0.411	-2.756
67	2013	0.079	0.000	-0.171	-0.318	0.122	0.000	-0.015	-0.001	0.138	0.447
68	2011	0.281	0.080	0.000	-0.188	0.068	0.000	-0.022	0.000	0.091	0.320
69	2011	0.478	0.000	0.267	0.275	-0.189	0.000	-0.056	0.001	-0.134	0.125
69	2012	-0.376	0.300	0.156	-0.122	0.079	0.000	-0.078	0.001	0.156	-0.789
70	2011	0.099	-0.037	-0.444	-0.428	0.168	0.000	-0.022	-0.001	0.191	0.840
70	2012	-0.124	0.000	-0.058	2.358	-1.005	0.000	-0.031	0.005	-0.979	-1.418

Appendix 8: Complete Results for the No Time Specification model (part 3/3)

id	Period (final)	TRS change	K change	L change	G change	TPF	TP	TE	SE	AE	random shocks
72	2011	0.002	0.031	0.004	0.126	-0.046	0.000	-0.011	0.000	-0.035	-0.113
72	2012	-0.110	-0.030	0.414	-0.013	-0.080	0.000	-0.016	0.000	-0.064	-0.401
72	2013	-0.031	0.000	0.000	-0.188	0.042	0.000	-0.022	0.000	0.064	0.115
74	2011	0.118	0.677	-0.139	0.537	0.150	0.000	-0.020	0.003	0.166	-1.107
75	2011	0.080	0.000	0.183	-0.446	0.126	0.000	-0.011	-0.001	0.138	0.217
76	2013	0.056	0.000	0.117	-0.429	0.010	0.000	-0.065	-0.001	0.076	0.358
77	2011	-0.226	-0.059	-0.462	-0.072	0.009	0.000	-0.028	-0.001	0.037	0.357
79	2013	0.081	0.000	1.008	0.278	-0.434	0.000	-0.050	0.001	-0.385	-0.771
80	2011	-0.045	0.000	0.017	0.255	-0.168	0.000	-0.112	0.001	-0.057	-0.148
80	2012	-0.079	0.000	-0.099	1.262	-0.451	0.000	-0.156	0.003	-0.298	-0.791

Source: Author's analysis