FUNDAÇÃO GETÚLIO VARGAS
ESCOLA DE PÓS-GRADUAÇÃO EM ECONOMIA

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Essays on Multi-Country Economic Growth and Sectoral Total Factor Productivity

Rio de Janeiro
2016

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Tese submetida à Escola de Pós-Graduação em Economia como requisito parcial para obtenção do grau de Doutor em Economia

Área de concentração: Desenvolvimento

Orientador: Pedro Cavalcanti Gomes Ferreira
Co-orientador: João Victor Issler

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2016

Ficha catalográfica elaborada pela Biblioteca Mario Henrique Simonsen/FGV

Ferreira, Mariana Fialho
Essays on multi-country economic growth and sectoral total factor productivity / Mariana Fialho Ferreira. – 2016.
182 f.

Tese (doutorado) - Fundação Getulio Vargas, Escola de Pós-Graduação em Economia.
Orientador: Pedro Cavalcanti Gomes Ferreira.
Coorientador: João Victor Issler.
Inclui bibliografia.

1. Desenvolvimento econômico. 2. Produtividade. I. Ferreira, Pedro Cavalcanti. II. Issler, João Victor. III. Fundação Getulio Vargas. Escola de Pós-Graduação em Economia. IV. Título.

CDD – 338.9

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"ESSAYS ON MULTI-COUNTRY ECONOMIC GROWTH AND SECTORAL TOTAL FACTOR PRODUCTIVITY "

Tese apresentada ao Curso de Doutorado em Economia da Escola de Pós-Graduação em Economia para obtenção do grau de Doutor em Economia.

Data da defesa: 03/11/2016

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Aos meus queridos avôs, Alzarides e Oldy, sempre presentes na memória.

Agradecimentos

Este trabalho simboliza e incorpora não apenas as aparentemente infindáveis horas de pesquisa e estudo, mas, sobretudo, o empenho daqueles que sempre torceram pelo meu sucesso e contribuíram de forma imensurável para o meu engrandecimento pessoal e profissional.

Em primeiro lugar, gostaria de agradecer aos meus pais, Ana Teresa e Antonio Augusto, por fazerem dos meus sonhos os deles, e não pouparem esforços para que se tornassem realidade. Muito obrigada por nunca me permitirem duvidar de que eu seria capaz de alcançar tudo aquilo que almejasse. Por estarem sempre presentes na minha vida, tanto nas horas mais difíceis como nas de comemorações. Meu amor por vocês é incondicional.

Ao meu esposo, Patrick, que ao longo do doutorado foi meu namorado, meu noivo, meu melhor amigo, meu porto seguro, meu amor. Obrigada por ser tão generoso e compreensivo. Não tenho palavras para agradecer a leveza que você trouxe para a minha vida. É por você que acordo todos os dias com a certeza de que estou no lugar certo, na hora certa. E é para você que eu tento me tornar um ser humano melhor.

À Dixie, por me ajudar a arejar a mente, obrigando-me a fazer pausas; nem sempre programadas, mas exigidas pelo mais puro olhar que existe.

Ao meu irmão, Pedro Henrique, por permitir que nossas discussões filosóficas madrugadas adentro não fossem afetadas pela distância ou pelo tempo. Não há absolutamente nada no mundo que eu não faria por você.

À minha avó e madrinha Léa, meu exemplo de determinação, força e resiliência. Ao tios Lauro Jair e Vera, por terem me acolhido com tanto carinho assim que cheguei ao Rio.

Aos irmãos que o doutorado me trouxe, Júlia Fonseca, Mariana Milhomem, Fernanda Jardim e Victor Duarte, meus fantásticos companheiros ao longo desta maratona, desde a largada. Obrigada por serem a mão amiga com a qual eu tinha a certeza de poder contar em qualquer circustância, tempo e lugar. Minha jornada teria sido absurdamente mais pesada sem a amizade e o carinho de vocês.

Aos amigos de Vitória, Luciana Cazoto, Marcos Guimarães, Vanessa Rozindo, Carol Berger, Victor Passos e Saulo Pratti, pela paciência em cultivar nosso convívio à distância a cada dia, sem deixá-lo esmorecer. Às amigas do Rio, Renata Moraes e Cinthya Bretz, por aceitarem fazer parte da minha família em terras cariocas, também composta pelos primos Alexandre e Joanna Terezan.

Aos estimados professores Rogério Arthmar e Robson Grassi (UFES), por terem feito nascer em mim a paixão pelas Ciências Econômicas, e Victor Gomes e Roberto Ellery (UnB), por me mostrarem o quão fascinante pode ser a pesquisa em Macroeconomia e, especialmente, em Crescimento Econômico.

Ao meu orientador Pedro Cavalcanti e co-orientador João Victor Issler (EPGE-FGV), agradeço imensamente toda a confiança que depositaram em mim, as horas de intensa dedicação à minha formação e ao trabalho que realizamos em conjunto e a exigência e incentivo com que o conduziram, os quais foram fundamentais para que eu me tornasse uma pesquisadora cada vez mais segura. Aos demais professores da Congregação da EPGE, por todos os ensinamentos transmitidos, dentro e fora de sala de aula. A convivência com cada um foi extremamente enriquecedora e singular. Aos demais funcionários da Escola, deixo também o meu muito obrigado pelo incomparável profissionalismo e sensibilidade, demonstrados a todo momento.

Agradeço, por fim, o apoio a mim concedido pela Fundação Getúlio Vargas e, em especial, pela Escola de Pós-Graduação em Economia. Foi uma verdadeira honra ter sido aluna dessa conceituada e tradicional Escola. Ao mesmo tempo, foi também uma grande satisfação pessoal ter aceitado este desafio que, como tal, envolveu inúmeros momentos de alegria e de renúncia, sempre acompanhados, contudo, pela absoluta certeza de que não havia caminho alternativo a ser seguido, que não o da excelência.

"For life is quite absurd
And death's the final word
You must always face the curtain with a bow
Forget about your sin - give the audience a grin
Enjoy it - it's your last chance anyhow"

Always Look on the Bright Side of Life
Monty Python's Life of Brian

Resumo

Nesta tese, oferecemos uma abordagem alternativa - e talvez mais apropriada - para a estimação da produtividade total dos fatores (PTF) setorial. Nossa economia artificial utiliza insumos produzidos por diferentes setores para produzir cada um dos bens, os quais, por sua vez, podem ser empregados como insumo ou consumidos pelo agente representativo em um arcabouço de equilíbrio geral. Essa estrutura de insumo-produto é adequada a uma ampla gama de exercícios, que podem ser desenvolvidos usando bases de dados que foram disponibilizadas apenas recentemente. No primeiro capítulo, construímos séries em nível e índices de produtividade para 35 atividades e 40 países, que respondem por mais de 85% do PIB mundial, e séries agregadas para países e para os 3 setores da economia. Nossos resultados sugerem que, na maioria dos países, o setor de serviços não apenas apresentou produtividade mais alta do que a indústria, mas também que a diferença de produtividade entre esses dois setores está aumentando com o passar do tempo. Esses resultados vão de encontro a algumas conclusões amplamente conhecidas, as quais foram elaboradas a partir de dados sobre a produtividade do trabalho. Isso ocorre principalmente pelo fato de a nossa abordagem possibilitar a mensuração da influência de todos os insumos produtivos sobre a produtividade total dos fatores. No capítulo 2, nós buscamos avaliar a importância quantitativa dos cost shares setoriais para o crescimento da produtividade setorial e agregada. Para tanto, realizamos uma análise comparativa relacionando as taxas de crescimento da PTF setoriais e agregadas dos EUA e do Brasil, e conduzimos dois conjuntos de exercícios contrafactuais. O principal propósito desses execícios é avaliar em que medida mudanças nos cost shares associados com o uso intermediário de produtos afetam o crescimento da produtividade setorial e agregada. A partir do primeiro conjunto de exercícios, concluímos que os melhores resultados - em termos de elevações no crescimento da PTF - parecem ser alcançados quando substituímos as participações da indústria doméstica brasileira no custo total de sua indústria pelos cost shares norte-americanos correspondentes, uma vez que elas são capazes de melhorar a PTF em um maior número de atividades e, consequentemente, estimular as taxas de crescimento da produtividade em todos os três setores e no agregado da economia. A partir do segundo conjunto de contrafactuais, concluímos que a escolha ótima de fornecedores estrangeiros, assim como o trade-off entre insumos domésticos e importados, como prescritos pelo modelo, são consistentes com um cenário de produtividade mais próspero. O capítulo 3 investiga os principais determinantes do crescimento econômico da América Latina e Caribe (LAC), levando em conta alterações no ambiente econômico da última década e contrastando a importância relativa de condições externas favoráveis com a de políticas públicas adequadas. Nós estimamos a equação de crescimento utilizando estimadores de métodos de momentos generalizados (GMM) desenvolvidos para modelos dinâmicos de dados em painel e, a partir dos coeficientes estimados, investigamos a contribuição de cada um dos grupos de determinantes para a variação esperada do crescimento econômico. Por fim, conduzimos um exercício contrafactual, objetivando quantificar em que medida os termos de troca favoráveis foram responsáveis pelo crescimento econômico recente da região da LAC. Nós concluímos que essa variável foi, de fato, um determinante significativo para o crescimento econômico dos países latino-americanos ao longo da década passada.

Palavras-chave: produtividade, PTF, crescimento econômico

Abstract

In this thesis, we offer an alternative - and perhaps more appropriate - analytical setup for estimating sectoral total factor productivity (TFP). The artificial economy uses inputs from different sectors in producing every commodity, which is either used as an input or consumed by the representative agent in a general equilibrium framework. This input-output structure is suitable for a wide range of exercises, which can be performed using datasets that only recently became available. In the first chapter, we construct 35-activity TFP indices and level series for a group of 40 countries, which responds for more than 85% of world GDP, and aggregate data to construct country-level and 3-sector indices and level series. Our findings suggest that, in most of the countries, the services sector not only has presented higher productivity than industry, but also that these differences are getting larger over time. These results are at odds with some widely known conclusions, which have been drawn from labor productivity data by previous work in the field. It occurs mainly because our framework enables us to quantify the influence of all productive inputs on total factor productivities. In chapter 2, we aim to evaluate the quantitative importance of sectoral cost shares in explaining sectoral and aggregate productivity growth. To this end, we perform a comparative analysis concerning sectoral and country-level TFP growth rates in the USA and in Brazil and conduct two sets of counterfactual exercises. The main purpose of these exercises is to assess to what extent changes in the cost shares associated with intermediate uses of outputs affect sectoral and aggregate total factor productivity growth. As a result of the first set of exercises, we find that the best outcomes - in terms of enhancing TFP growth - seem to be achieved when we replace Brazil's shares of its domestic industry in the total cost of its industry by the corresponding cost shares of the US economy, since they are able to improve TFP in a higher number of activities and, as a result, to boost TFP growth rates in all three sectors and in total economy. From the second set of counterfactuals, we conclude that the optimum choice of international suppliers, as well as the trade-off between domestic and imported inputs, as prescript by the model, are consistent with a more flourishing productivity scenario. Chapter 3 investigates the main determinants of economic growth in Latin America and the Caribbean (LAC), considering changes on last decade's economic environment and measuring the relative importance of favorable external conditions and of proper public policies. We estimate a growth equation using generalized method of moments (GMM) estimators designed for dynamic models of panel data and, from the estimated coefficients, we assess the contribution of each group of determinants to expected change on economic growth rates. At last, we conduct a counterfactual exercise, aiming to evaluate to what extent enabling terms of trade were responsible for recent LAC's economic growth. We find that this variable was, indeed, a significant determinant for latin american countries' economic growth over the last decade.

Keywords: productivity, TFP, economic growth

Lista de Figuras

Lista de Tabelas

Sumário

Capítulo 1

On Deriving Evidence from Input-Output Linkages: A Multi-Country Sectoral Total Factor Productivity Analysis

1.1 Introduction

Over the last decades, a relevant strand of the macroeconomic literature has sought to uncover the sources of differences in income across countries. A substantial number of studies has pointed out the primary importance of cross-country differences on labor productivity and total factor productivity (TFP)[1] in explaining large shares of differences in income. Moreover, new branches of this literature have dedicated great efforts to show how sectoral differences in productivity drive the process of reallocation of factors between the many activities of an economy and, ultimately, can account for the aggregate productivity outcomes.

It is relevant to note that there have been some well recognized obstacles posed to this potentially fruitful agenda. For instance, as stressed by Duarte and Restuccia (2015) until the recent release of the World Income-Outcome Database (Timmer, M. P. et al. (2015)), sources of comprehensive sectoral data were scarce.

That said, in order to assess the contribution of sectoral productivity to aggregate outcomes, researchers in the field had to rely on expenditure data to establish patterns of sectoral productivity across countries. However, some inferences made from expenditure price data may be misleading.

As argued by Duarte and Restuccia (2010), the conventional wisdom about price-level differences across country was typically built upon expenditure prices (e.g., from PWT or ICP) instead of producer prices. This led, for example, to the widely spread idea that the relative prices[2] of agriculture and services are higher in rich than in poor countries. By claiming that food is cheap in poor countries, within this specific category of analysis, what is really being stated is that food expenditures are higher in rich countries. However, food expenditures include distribution and other charges so that, depending on the country under scrutiny, it may imply in a significant disparity between these prices and the ones faced by producers. On the other hand, the model of structural transformation proposed by Duarte and Restuccia, which has implications for producer prices, generates diametrically opposed results: the dispersion in productivity across rich and poor countries is larger in agriculture and services relatively to manufacturing, implying that relative prices are higher in poor than in rich countries.

[1] In this paper, we use the expressions "total factor productivity", "TFP"and "productivity"interchangeably.
[2] Relative to manufacturing.

The World Input-Output Database (WIOD)[3] may be described as the most up-to-date and comprehensive sectoral cross-country database. This brand new database enables a wide range of sectoral studies, as it provides data for 35 economic activities and 40 countries, from 1995 to 2009. Besides compiling a large amount of multilateral data in its World Input-Output Tables (WIOTs), the Socio-Economic Accounts (SEA) also contains disaggregated data on output, wages and employment and capital stock.[4]

For our purposes, the most interesting feature of the WIOTs is that they are valued at basic prices, i.e., all values in their intermediate and final use blocks represent the amount receivable by the producer from the purchaser. The construction methodology of these tables guarantees that the trade and transport margins cannot interfere in their valuation, as they are recorded in separate rows.[5] In other words, the valuation method adopted ensures that our results are not going to be dictated by expenditure prices, and thus it secures our conclusions against producing misleading inferences.

Another limitation for quantitative sectoral productivity studies is the fact that, up to the present date, there are no activity-level total factor productivity series available. Even though some estimates of labor productivity for a large set of countries and disaggregated activities have already been made[6], actual data on total factor productivity is not yet available. However, theory says that total factor productivity is one of the main drivers of cross-country growth.

The main reason for the absence of sectoral TFP data is that disaggregated capital stock series are not available for most of the countries. More precisely, official sectoral capital stock data is available only up to 2007, and for a very limited set of OCDE countries in the EU KLEMS database. The WIOD computed, also only up to 2007, series for the remaining countries covered by the database on the basis of the Perpetual Inventory Method. To accomplish that, certain assumptions concerning the depreciation rates had to be made and, for those countries whose investment series were too short, the initial capital stock had to be estimated.[7]

In this paper, we offer an alternative - and perhaps more appropriate - analytical setup for estimating sectoral TFP. We employ the seminal contribution of Long and Plosser (1983) to the real business cycle literature to construct total factor productivity (TFP) measures that are multi-country and multi-sector. This is a novel approach, since the previous literature has used only labor productivity measures to discuss long-run growth.[8]

Long and Plosser focused mainly on showing how a simple general equilibrium model, built upon standard assumptions regarding individual's preferences and production possibilities, was capable of explaining certain business cycle regularities. Subsequent work on the field, e.g., Durlauf (1989) and Engle and Issler (1995), worried about the dynamic properties of the data in terms of common trends and common cycles. So far, no one has used the model to construct sectoral TFP measures, something that is lacking in TFP literature.

The artificial economy proposed here uses inputs from different sectors in producing every commodity, which is either used as an input or consumed by the representative household in a general equilibrium framework. This input-output structure is suitable for a wide range of cross-country exercises that can be performed using datasets that only recently became available.

In short, by combining worldwide data from the WIOD and the input-output linkages of the model, we are now able to calculate sectoral total factor productivity for a set of countries that respond to more than 85% of world's GDP. Due to the deepening of the globalization process, it is imperative for the economic growth literature to investigate to what extent global value

[3] Which includes the World Input-Output Tables (WIOTs) and the Socio Economic Accounts (SEA).

[4] Although there are annual WIOTs until 2011, labor data obtainable from SEA is only available for the full set of 40 countries until 2009.

[5] See Timmer, M. et al. (2012b).

[6] See Duarte and Restuccia (2010), Duarte and Restuccia (2015) and Inklaar and Timmer (2014)

[7] For more information, see Timmer, M et al. (2012b).

[8] For instance, see Baumol (1967), Baumol et al. (1985), Baumol (1986), McMillan and Rodrik (2011), Rodrik (2013), Herrendorf et al. (2014), and Ferreira and Silva (2015).

chains are important for a given country's sectoral productivity and, therefore, for its aggregate outcomes.

We first construct 35-activity TFP indices and level series for a group of forty countries. We then aggregate data to construct country-level and 3-sector indices and level series, so that we can extract some new insights and compare our country-level data. Our findings suggest that, in most of the countries, the services sector not only has presented higher productivity than industry, but also that these differences are getting larger over time.

In fact, our results are at odds with some widely known conclusions, which have been drawn from labor productivity data by previous work in the field. It occurs mainly because our model enables us to quantify the influence of all productive inputs over total factor productivities.

This paper is organized as follows. In the next section, we present the model that theoretically supports our subsequent accounting exercises. In Section 3, we describe the database adopted for our quantitative analysis, the identification strategy we chose to apply and the main steps for the computation of the TFP level series for the 35 economic activities, for the 3 sector aggregation and for the country-level aggregation. Section 4 provides the main results. Section 5 concludes.

1.2 The Model

1.2.1 Dynamic General Equilibrium: Open Economy Setup

In this section, we present the framework that gives support to our empirical analysis. We closely follow the real business cycle setup proposed by Long and Plosser (1983), but we implement some adjustments in order to match an environment that contains many heterogeneous open economies.[9]

Due to the increasing globalization of value chains, there is a growing number of goods and services that are no longer produced within a single country. Therefore, to capture the impacts of international trade of goods and services over each sector, we assume that there are C countries in our economic environment, in which I different industries operate.

The individual who solves the maximization problem that will be described in the following sections thus may have to consider the allocation of up to $N = I \times C$ commodities. In other words, an activity i, $i \in \{1, 2, ..., I\}$, whose production is specialized in one single sort of commodity, may have up to C different "plants"producing it, each of them based in one of the C countries.

The commodities' characteristics thus have two important dimensions. First, they differ in their own "nature", e.g., one of the produced commodities may be labelled as "textiles and textile products", belonging to the wider group "manufacturing", and another one may be assigned to "hotels and restaurants", belonging to "services". Second, they can be domestically produced or imported from other countries.

Therefore, when deciding which inputs to employ in a given production process, or when establishing his consumer basket for the period, the agent have to take into account the allocation both the domestically produced commodities and the ones produced abroad.

The timing of the events in this economy can be described as follows: at the beginning of each period, the individual chooses (i) his consumption plan, i.e., the commodity bundle and the amount of leisure (in time units) he is willing to consume during the period and (ii) his production plan, i.e., quantities of all commodities and labor (in time units) inputs to be allocated in every productive transformation that takes place (and it is concluded) during the period.

During every period, various random shocks modify the productive transformations, although they cannot influence the individual's tastes. Thus, the total commodity stocks that will be

[9] Long and Plosser's original model is suitable only for the analysis of a single closed economy.

available at the beginning of the subsequent period are derived from the combined result of the input choices made at the beginning of the current period and the random shocks to the production activities that occur along the period.

1.2.2 Economic Environment

Preferences

The model's economy has a single infinite-lived individual (or a constant number of identical individuals), endowed with initial resources, production possibilities and preferences. The individual then has to choose, based on his marginal rate of substitution, a preferred consumption-production plan.[10] The economic activities in this environment may be summarized as repetitions of one-period cycle, each of them beginning with this individual's choice problem (or, similarly, the representative agent's problem).

At the beginning of the period the individual chooses a consumption-production plan that maximizes the value of his expected discounted utility, constrained by the availability of resources and the production possibilities. At $t = 0$, the individual's utility U is given by:

$$U = \sum_{t=0}^{\infty} \beta^t u(C_t, Z_t), \qquad 0 < \beta < 1 \tag{1.1}$$

where β is a discount factor, C_t is a N-vector of commodity consumption at time t, and Z_t is the total amount of leisure (measured in time units) consumed in period t. As we can clearly notice from equation (2.1), preferences are assumed to be constant over time, i.e., there are no exogenous random shocks influencing the individual's tastes.

The one-period utility, $u(C_t, Z_t)$ is of the form:

$$u(C_t, Z_t) = \theta_0 \ln Z_t + \sum_{i-1}^{N} \theta_i \ln C_{i,t} \tag{1.2}$$

where $\theta_i \geq 0, i = 0, 1, \ldots, N$, and, in general, $\theta_0 > 0$. In this case, even if some commodity k has no direct consumption value, i.e., $\theta_k = 0$, it does not mean it is completely useless for the individual. It is important to have in mind that it may also serve as a input in the production of commodities.

Production Function

One important feature of this economy is that all commodities are produced. In this sense, any commodity may serve as an input in the production of others (and possibly in its own), and the production of a given commodity depends on positive quantities of other commodities. It is also assumed that every commodity in this economy is "perishable", which means that the available commodity stocks at the beginning of each period are composed entirely by units produced during the previous period. In other words, it is assumed a depreciation rate of 100% per period.[11]

The production possibilities exhibit constant returns of scale and take the form:

$$Y_{t+1} = F(L_t, X_t; \lambda_{t+1}) \tag{1.3}$$

[10] It is interesting to observe that the optimal plan and the individual's marginal rate of substitution can be interpreted as, respectively, the quantities and relative prices at a competitive market economy, therefore being capable of generating multi sector rational expectations equilibria.

[11] This assuption, although not being essencial the model, simplifies the solution to the recursive problem.

where Y_{t+1} is a N-vector, and its ith element, $Y_{i,t+1}$, is given by the total stock of commodity i available at time $t+1$, $F(\cdot,\cdot;\cdot)$ is a N-vector-valued function, assumed to be concave and linearly homogeneous with respect to L_t and X_t, L_t is a N-vector whose ith element, $L_{i,t}$, is given by the number of hours allocated at time t to the production of commodity i, X_t is a matrix of order $N \times N$ and its i,j element, $X_{ij,t}$, is given by the amount of commodity j allocated to the production of commodity i at time t, and λ_{t+1} is a random vector whose value is realized at time $t+1$. It is also assumed that the vector-valued stochastic process $\{\lambda_t\}$ is an observable, time-homogeneous Markov process.

The production functions are assumed to be of the following form:

$$Y_{i,t+1} = \lambda_{i,t+1} L_{i,t}^{b_i} \prod_{j=1}^{N} X_{ij,t}^{aij} \tag{1.4}$$

where $b_i \geq 0, i = 1, \ldots, N$, $a_{ij} \geq 0, i, j = 1, \ldots, N$ and $\sum_{j=1}^{N} a_{ij} + b_i = 1, i = 1, \ldots, N$.

Note that, except from the stochastic technological parameters $\{\lambda_t\}$ - which are, precisely, the total factor productivity vectors we are interested on - this is a standard Cobb-Douglas technology.

Some considerations regarding $\{\lambda_t\}$ - which denotes the infinite stochastic sequence $\lambda_0, \lambda_1, ..., \lambda_t$ - are worth to be made. As it was assumed that this sequence follows a time-homogeneous Markov process, it has the property that the conditional distribution of $\lambda_{t+\tau}$, $\tau > 0$, given $\lambda_t, \lambda_{t-1}, \lambda_{t-2}, ...$depends only on τ and on the value of λ_t. This is equivalent to saying that these processes are uniquely defined by a "one-step-ahead"conditional distribution function, $G(\lambda_{t+1}|\lambda_t)$. But this assumption does not constrain the process to be stationary or to have no drift. It also does not constrain individual elements or scalar-valued functions of λ to be Markov processes.

Therefore, since the production function F does not depend on the value of t per se, technological change can be represented by drift and/or time-series dependence on the process $\{\lambda_t\}$.On the other hand, if the vectors in $\{\lambda_t\}$ are independent and identically distributed (i.i.d.), there is no technological change. As there is a wide range of both theoretic and empirical studies documenting the primary impacts of technological change on economic growth, we can expect our series to follow a process with a drift and/or time-series dependence; i.e., the observable shocks will not be i.i.d..

Moreover, the individual's choices are constrained by the amount of time (fixed, that must be allocated between leisure and work) and by the total commodity stocks that are available at the beginning of each period. These two resource constraints should be satisfied at each period.

The first one concerns the labor/leisure choices. If H denotes the total fixed stock of time available per period, then:

$$Z_t + \sum_{i=1}^{N} L_{i,t} = H, \qquad t = 0, 1, 2, \ldots \tag{1.5}$$

The commodity allocation constraint is given by:

$$C_{j,t} + \sum_{i=1}^{N} X_{ij,t} = Y_{j,t}, \qquad j = 1, 2, \ldots, N; \qquad t = 0, 1, 2, \ldots \tag{1.6}$$

Lastly, the decision variables - the allocations (C_t, Z_t, L_t, X_t) - chosen by the individual at time t, are assumed to depend only on observable information at time t. Hence, with $S_t \equiv (Y_t, \lambda_t)$ denoting the state vector at time t, the allocations at time t are functions of S_t.

Expected Utility Maximization

The individual then must choose a consumption-production plan at time t to maximize his expected utility, given by

$$E\left(U|S_t\right) = \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s, Z_s)|S_t\right] \tag{1.7}$$

subject to the production possibilities constraint (2.4) and to the two resource constraints (2.5) and (2.6).

Furthermore, the individual's preferences are such that if the welfare function, $V(S_t)$, is defined as the maximum value of $E\left(U|S_t\right)$,

$$V(S_t) \equiv \max \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s, Z_s)|S_t\right]$$

s.t. (2.3), (2.5) and (2.6)

$$= \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C(S_t), Z(S_t))|S_t\right] \tag{1.8}$$

then V and the optimal allocation plan are jointly the solution to:

$$V(S_t) = \max_{d_t} \left\{u(C_t, Z_t) + \beta E\left[V\left(S_{t+1}\right)|S_t\right]\right\} \tag{1.9}$$

where d_t stands for all current decision variables at time t, which are: $L_{i,t}$, $C_{i,t}$, $X_{ij,t}$, $i, j = 1, \ldots, N$.

In general, this functional equation does not admit a closed form solution. However, besides restricting the utility function to be logarithmic, the additional assumption of a Cobb-Douglas technology fulfill the set of sufficient conditions that guarantee a analytic (closed form) solution to this problem.[12]

Moreover, functional equations like the Bellman equation (2.9) are solved by iterative procedures or by guess and verify. Long and Plosser (1983) provided the following value function, i.e., the solution to the individual's intertemporal maximization problem:

$$V(S_t) = \sum_{i=1}^{N} \gamma_i \ln Y_{i,t} + J(\lambda_t) + K \tag{1.10}$$

where $\gamma_j = \theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij}$, $j = 1, 2, \ldots, N$, $J(\lambda_t) = \beta E\left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1})|\lambda_t\right]$ and K is a constant that only relies upon on preference and production parameters, but not on state variables, Y_t or λ_t.

Following Long and Plosser (1983), this solution can be obtained by "dumb luck", due to the particular preferences and production possibilities assumed. However, the validity of this solution for V can be verified by the following steps. First, assume V is given by (2.10). Then, do the maximization with respect to time t consumption and input decisions on the right-hand side of (2.9). Finally, note that the maximum on the right-hand side of (2.9), as a function of S_t, is given by $V(S_t)$ as defined by (2.10). For the complete reasoning, see Appendix 1.

[12] See Christiano (1990) and Mehra (2005).

Optimal Quantities

Solving (2.9), one can show (see Appendix 1) that, at time t, optimal consumption, leisure, commodities and labor inputs are, respectively, given by:

$$C^*_{i,t} = \left(\frac{\theta_i}{\gamma_i}\right) Y_{i,t}, \qquad i = 1, 2, \ldots, N \tag{1.11}$$

$$Z^*_t = \theta_0 \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i\right)^{-1} H, \tag{1.12}$$

$$X^*_{ij,t} = \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j}\right) Y_{j,t}, \qquad i, j = 1, 2, \ldots, N \tag{1.13}$$

$$L^*_{i,t} = \beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j\right)^{-1} H, \qquad i = 1, 2, \ldots, N \tag{1.14}$$

where $\{\gamma_j\}$ is given by $\gamma_j = \theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij}$, $j = 1, 2, \ldots, N$.

It becomes explicit in equation (2.11) that the portion of the total available stock of a given commodity allocated to final consumption is directly proportional to its consumption value. Similarly, as one can see in equation (2.13), the amounts of a commodity allocated as an input in the production of a given commodity (and possibly in its own) is an increasing function of its productivity in that employment. Also, from equations (2.12) and (2.14), note that the same principle applies to the allocation of the total fixed stock of time available per period.

On the other hand, the aforementioned equations show that the bigger the total available stock of a given commodity (or time), the more intensive will be its allocation as a productive input and to positively valued consumption (or leisure). Long and Plosser (1983) highlighted this principle as being the most important feature of the optimal decision rules, specially (2.13), in that it is the primary source of persistence and comovement in the consumption, input and output series.

To understand how these propagation mechanisms work, suppose that, at time t, a TFP shock to the output makes the total available stock of a given commodity unexpectedly high. Then, at time t, the inputs of this commodity in all of its alternative employments will also be unexpectedly high. It is equivalent to saying that, in this model, shocks not only propagate forward in time, but also generates future effects that spread across the sectors of the economy.

Other three aspects of the decision rules are worth noting. First, at time t, the allocation of a given commodity (or time) does not depend on the available amounts of other commodities. Second, given the total available stock of output at time t, none of the allocations depends on λ_t.Third, as the labor/leisure allocations are also independent of Y_t and, by assumption, the total stock of time remains constant, these allocations do not change over time.[13]

Dynamics

One of the most interesting features of this setup is its capability of generating an extremely simple and intuitive equation for the dynamics of output. This can be verified by substituting the optimal values of the production inputs, given by (2.13) and (2.14), into the production function (2.4) and taking logs. Letting $y_t \equiv \{\ln Y_{i,t}\}$ denote a $N \times 1$ vector of outputs, we obtain:

[13] In other words, the model do not reproduce the procyclical behavior of labor employment. There is an extensive related discussion in Long and Plosser (1983).

$$y_{t+1} = Ay_t + k + \eta_{t+1} \tag{1.15}$$

where A is the $N \times N$ matrix of parameters $\{a_{ij}\}$, k is a $N \times 1$ vector of constants and η_{t+1} is the $N \times 1$ stochastic vector $\{\ln \lambda_{i,t+1}\}$.

The elements of the A matrix are, by construction, the elasticities of commodity outputs with respect to commodity inputs.[14] As it will become clear on section 3.2, some of the model's assumptions facilitate the identification of the parameters' values from available information in our database.

The hypothesis that many commodities are used as inputs in the production of many (commodity) outputs directly implies that many columns of the A matrix are full of positive elements. The relevance of this assumption can be observed from the dynamic behavior of the output, given by (2.15).

Suppose that, at time t, the output of a given commodity i, $y_{i,t}$, corresponding to one of these columns is unexpectedly high. For instance, this may occurr due to an unexpected technological shock that shifted up the value of the total factor productivity parameter $\lambda_{i,t}$ of this specific sector (which obviously made $\eta_{i,t}$ also higher and, consequently, increased the value of $y_{i,t}$). Then, in $t+1$, the outputs of all of the commodities that employed commodity i as productive input will also be higher. This is, precisely, the mechanism that drives the propagation of exogenous shocks both through time and across sections that we have explained in the previous section.

It is straightforward to show that the ith element of vector y_t is given by:

$$y_{i,t+1} = \sum_{j=1}^{N} a_{ij} y_{j.t} + k_i + \eta_{i,t+1} \tag{1.16}$$

where

$$k_i = b_i \ln \left[\beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H \right] + \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right) \tag{1.17}$$

Note that if we consider the admissible - yet unrealistic - scenario in which the vectors in the sequence $\{\lambda_t\}$ are iid, then the A matrix is the only responsible for the intertemporal links between deviations of outputs from their expected values. Moreover, the preference parameters (β and θ_i, $i = 0, 1, .., N$) influence the dynamics of outputs, as the vector of constants k is a function of them.[15]

[14] They have been already defined together with other elements of the production function (2.4) and its main features will be discussed in the next sections.

[15] Due to the format of the other variables' allocation rules, e.g. consumption and production inputs, the dynamic behavior of these varibles can be directly obtained from the dynamics of outputs.

1.3 Data and identification strategy

1.3.1 Data

In this paper, we use data from the World Input-Output Database (WIOD), which provides time-series for 35 economic activities and 40 countries worldwide and a model for the rest-of-the-world.[16]

Most part of products and services are no longer produced by a single activity, or even within a single country. This fragmentation has been stimulating a significant number of studies and public policies towards the relevance of the global value chains, particularly in the last two decades. However, these analyses were irremediably constrained by the lack of an appropriate sectoral database. Actually, this is the same reason why quantitative sectoral productivity studies had remained in the shadows for so long, despite the importance of measuring the contribution of sectoral productivity to the aggregate productivity of the economies.

The WIOD has properly filled this gap, since it encompasses world sectoral data in a coherent framework that presents the indispensable features of being global and of covering changes over time in order to evaluate past developments.[17]

Even though this database covers only forty countries, they respond to more than 85% of world GDP.[18] The construction methodology of its series differs from many previously employed methods, mostly to guarantee the robustness of the analysis over time, an indispensable feature for the purposes of this paper.[19]

Moreover, it is possible to construct multi-country sectoral time series for total factor productivity by merely combining data provided by two of WIOD's four datasets: the World Tables, which include the WIOTs and the Socio-Economic Accounts (SEA). It is important to stress that both datasets cover the same sets of countries and activities, and present data for the period from 1995 to 2009.

From the Socio-Economic Accounts (SEA), we obtain the variable "labor compensation"for each of the 35 activities in the 40 countries covered by the dataset. The information this variable contains will be crucial to the computation of the sectoral total factor productivity series, as it influences each activity's cost shares magnitudes.

The second and last series we extract from the SEA are the "price levels of gross output". Since the WIOTs' values are available in current prices (dollars), we use these indices to compute gross output series in constant prices (the base year chosen whas the first one available, 1995).

For every year in the sample span (1995-2009) and for each of the 40 countries, the World Input-Output Tables (WIOTs) provide values of intermediate inputs (alternatively labeled "intermediate consumption") for their 35 domestic economic activities, disaggregated by country and by economic activity of origin. Each of these series' values represents how much a given

[16] The following series have missing data, and so they do no enter our calculations:

(i) Private Households with Employed Persons in: Australia, Bulgaria, Brazil, China, Estonia, Hungary, Indonesia, Japan, Korea, Latvia, Romania, Russia, Slovak Republic and Spain;

(ii) Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel in: China and Indonesia;

(iii) Coke, Refined Petroleum and Nuclear Fuel in: Cyprus, Luxembourg, Latvia and Malta;

(iv) Leather, Leather and Footwear in: Luxembourg and Sweden.

[17] For further information concerning this features or the underlying principles and choices for the construction of the WIOD, see Dietzenbacher, E. et al. (2013).

[18] The countries covered are: Australia, Austria, Belgium, Bulgaria, Brazil, Canada, China, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Indonesia, India, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Mexico, Malta, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Sweden, Turkey, Taiwan and United States. Hence, the WIOD covers 27 EU countries and 13 other major countries. All remaining countries are proxied by a region called "Rest of the World (RoW)", which had to be modelled due to the lack of sufficient data.

[19] The difference from available alternative methods is twofold: first, it relies on national supply and use tables (SUTs) rather than on national input-output tables; second, its starting point are the output and final consumption series available in the national accounts. The national SUTs are then benchmarked to these time-consistent series.

intermediate input costs to a certain producer, i.e., the net value (excluding transport margins and net taxes) paid from a producer to a specific supplier. Alternatively, it gives the exactly amount received by a given producer from a specific purchaser of his products.

Note that, as we are dealing with 1400 "type-and-country-denominated" economic activities (as the dataset covers 35 activities and 40 countries), each of these bilateral trades involve producers that may operate in the same activity or in different ones, and that can be based at the same country or even at different continents.

Moreover, one of the bottom lines of a given year's WIOT, labeled "total intermediate consumption", displays, for each activity depicted by the table's columns, the values of its total intermediate input costs. In other words, the "total intermediate consumption" value associated with a column j representing activity j sums up each "intermediate consumption" net expenditure of this activity with all of its intermediate inputs.

To construct the A matrices of cost shares, it is necessary to evaluate the cost share of a input in the production of a output, for all pairs of activities. This can be done by dividing the value of the i, j-th element of the "intermediate consumption" block - which corresponds to the cost of input i in the production of output j - by the sum of activity j's "labor compensation" and "total intermediate consumption". Proceeding in this way for every i, j pair relative to a activity j's labor and intermediate input costs, and repeating this calculation for every industry covered by the dataset, we obtain a 1400×1400 matrix of cost shares. Since the WIOD covers 15 years (1995-2009), we will construct 15 of these matrices, one for each year available.

Finally, two important observations concerning this database must be made. First, the WIOTs are valued at basic prices, i.e, the values that appear in the intermediate blocks correspond to the amount the producer received from the purchaser. This valuation category ensures that both trade or transport margins and net taxes on products, to be paid by the purchasers, appear in specific rows.

Note that this basic price valuation matches our purposes, for it best reflects the underlying cost structures of economic activities, by separating the use of goods from the use of trade and transport services. As argued by Timmer et al. (2012b), this valuation strategy suits well input-output analysis in which production technology plays a central role.

Second, while the SEA's series are denominated in national currencies, the WIOTs' ones are denominated in US dollars. Fortunately, the exchange rates that were adopted to convert national values into US dollars are available, so we can perform interesting and coherent exercises in local currencies.

1.3.2 Identifying the series' components

Rearranging (2.15), we obtain an equation for the log of the sectoral total factor productivities:

$$\eta_{t+1} = y_{t+1} - Ay_t - k \tag{1.18}$$

As annual sectoral output data is readily available at the WIOTs, we face only two challenges in order to derive the values of the TFP shocks: one is to construct the A matrix, and the other is to obtain the vector of constants, k.

The vector k is a function of the preferences and technology parameters of the model, i.e., it does not depend on the state variables $S_t = (Y_t, \lambda_t)$. Obtaining k is of the utmost importance, as it allows computing sectoral TFP levels.

By construction, the elements of the A matrix are the elasticities of commodity outputs with respect to commodity inputs. However, due to the hypothesis of constant returns of scale, these elasticities are equal to the equilibrium cost shares, i.e., a_{ij} is the equilibrium share of input j

in the cost of output i, and so it can be expressed by the ratio:

$$a_{ij} = \frac{P_{j,t} X^*_{ij,t}}{W_t L^*_{i,t} + \sum_{k=1}^{N} P_{k,t} X^*_{ik,t}} \tag{1.19}$$

Accordingly, the A matrix is an input-output matrix, in terms of cost shares. Because we have presumed that each commodity may serve as an input in the production of a great number of different commodities, many columns of this matrix are often full of positive elements. Besides, the sum of all the elements that compound a given row of the A matrix must be equal to one minus labor's cost shares, and, for this reason, it is appropriate to say that it measures the capital intensity of the corresponding sector:

$$\sum_{j=1}^{J} a_{ij} = 1 - b_i$$

Our first step is to construct A matrices using data from the WIOTs, one for each period of time covered by our dataset. With this specific target in mind, we search for data on "labor compensation"and on the "value of intermediate inputs"for every possible economic activity, i.e, at the highest available degree of disaggregation of the ISIC 3.0 classification. We combine data from the Socio-Economic Accounts (SEA) and the World Input-Output Tables (WIOTs) to construct fifteen A matrices, one for each period (1995 to 2009). Moreover, the WIOD covers 35 economic activities and 40 countries, so that each A matrix will be a 1400×1400 square matrix.

Note from equation (2.19) that the i, j element of these matrices, a_{ij}, represents the equilibrium share of input j in the cost of output i. From the WIOTs, we obtain, for each of the 40 countries, values of intermediate inputs (alternatively labelled "intermediate consumption") for their 35 domestic economic activities, disaggregated both by country and by activity of origin. Each of these series' values gives the exact amount received by a given producer j from a specific purchaser of his products i.[20] Thus, we use this data as proxies for the corresponding $P_{j,t} X^*_{ij,t}$ products.

Furthermore, from these same tables we obtain the "total intermediate consumption" for each of the 1400 "type-and-country-denominated" activities, which sums up each "intermediate consumption" net expenditure of a given activity with respect to all of its intermediate inputs. This aggregate value, in turn, is used as a proxy for each of the $\sum_{k=1}^{N} P_{k,t} X_{ik,t}$ sums. Lastly, from the SEA table we obtain the variable "labor compensation"for each of the 35 activities in the 40 countries covered by the dataset, which we use as proxies for the $W_t L^*_{i,t}$ products.

In short, by gathering information from the WIOTs and the SEA, we construct fifteen A matrices of cost shares, of order 1400×1400, one for each year of the period from 1995 to 2009. Moreover, as the model imposes that the elements of this matrix do not change over time, we work with an averaged matrix, for its elements to be time-invariant, as assumed by the theory.

The second challenge was to identify the vector k. Note from equation (2.17) that k is a vector of constants, whose ith element is given by:

$$k_i = b_i \ln \left[\beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H \right] + \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right)$$

But recall that, by rearranging the equations for the equilibrium quantities of commodities

[20] Actually, we have to transpose the original WIOTs, to match our notation.

and labor inputs - equations (2.13) and (2.14), respectively - we have that:

$$\left(\frac{\beta\gamma_i a_{ij}}{\gamma_j}\right) = \frac{X^*_{ij,t}}{Y_{j,t}}, \qquad i,j = 1,2,\ldots,N$$

and

$$\beta\gamma_i b_i \left(\theta_0 + \beta\sum_{j=1}^{N}\gamma_j b_j\right)^{-1} H = L^*_{i,t}, \qquad i = 1,2,\ldots,N$$

Then, properly replacing these equivalences on the equation for each ith element of vector k gives us:

$$k_i = b_i \ln\left(L^*_{i,t}\right) + \sum_{j=1}^{N} a_{ij}\ln\left(\frac{X^*_{ij,t}}{Y_{j,t}}\right), \qquad t = 1,2,...$$

$$k_i = b_i l^*_{i,t} + \sum_{j=1}^{N} a_{ij}\left(x^*_{ij,t} - y_{j,t}\right), \qquad t = 1,2,... \tag{1.20}$$

where $l^*_{i,t} \equiv \ln L^*_{i,t}$, $x^*_{ij,t} \equiv \ln X^*_{ij,t}$ and $y_{j,t} \equiv \ln Y_{j,t}$.

A particular feature of equation (2.20) is worth noting. Although, by construction, vector k is a function of the preferences and technology parameters of the model - as we note from equation (2.17) - and, given this, it does not depend on the state variables $S_t = (Y_t, \lambda_t)$ - we have shown that its equation can be rewriten as a function of the optimal quantities of both commodities and labor inputs at each time period, t.

At first, these two statements may seem inconsistent. But, if on the one hand, we have already shown that the optimum allocation of labor hours does not change over time, on the other hand, for every sector i, the optimal shares of each input j allocated for the production of output i relative to the total available quantity of the same input does not change over time either. Therefore, each entry of vector k is a constant.

However, when we look at the data on hours worked, our *proxy* for labor input, and on the shares of each input used at a given sector over its total existing amount, we find that, in fact, these quantities are not time invariant. To circumvent these findings, which are at odds with our model's predictions, we proceed the exact same way we did when constructing the A matrix: we first identify 15 vectors k, one for each year from 1995 to 2009, which are of order 1400×1. But we end up working with an averaged (time-invariant) vector.

Fortunately, all of the components of equation (2.20) are directly obtainable from the SEA and the WIOTs. The former provides sectoral annual data for total hours worked by persons engaged, which we use as a *proxy* for the number of hours allocated at each year to the production of the N commodities (i.e., $L^*_{i,t}$, $i = 1,...,N$). Sectoral labor's cost shares (b_i, $i = 1,...,N$) and the commodities' cost shares (a_{ij}, $i = 1,...,N$, $j = 1,...,N$) have already been computed for the construction of the A matrices, whose elements, as we have shown, depend only on variables directly drawn from the SEA and the WIOTs. At last, from the latter, we obtain annual sectoral data both for bilateral intermediate consumption, which *proxies* for the amount of each commodity input allocated to the production of each commodity output (X_{ij}, $i = 1,...,N$, $j = 1,...,N$) , and for annual sectoral gross output at basic prices ($Y_{i,t}$, $i = 1,...,N$).

In sum, we have access to all sufficient sectoral information to construct series for each sectoral k_i, the last variable needed for the computation of the multi-country sectoral TFP levels given by equation (2.18).

Solving for the sectoral TFP levels in (2.18), we compute annual level series of TFP for the thirty-five activities, by country, at fourteen years (from 1996 until 2009). These levels can also be translated into indices of sectoral TFP - reflecting sectoral TFP growth rates, by normalizing the initial level values of the series (1996=100) for the forty countries in the sample.

The main products of this first exercise are 1400 series (for 35 activities and 40 countries) of multi-country sectoral TFP levels and indices of multi-country sectoral TFP, both sets denominated in constant[21] national currencies.

1.4 Multi-Country Sectoral Total Factor Productivity Series

1.4.1 3-Sector and Country-level Aggregation

To exemplify the relevance of these series and to gain intuition from them, we first aggregate the 35 activities we have been working with into 3: agriculture, industry and services, according to correspondence depicted on Table 1, presented in the end of Appendix 3. All of the aggregation procedures are conducted at the levels of the intermediate consumption, gross output, labor compensation and hours worked, i.e., at the series directly obtained from the WIOD. Only after that, we redo each of the calculations detailed over the last section.

After aggregating the thirty-five activities into three major sectors, the A matrix become of order 120×120 and the vector k of order 120×1. This new exercise provides 120 series (related to 3 sectors and 40 countries) of multi-country sectoral TFP levels and indices of multi-country sectoral TFP, denominated in national currencies.

Our 35-activity and 3-Sector level series and indices are an unprecedented contribution, as previous studies have used only labor-productivity measures to discuss long-run growth. So far, no one has used this proposed methodology to support the formulation of sectoral TFP measures.

Since this is a novel approach, we are unable to compare our disaggregated measures with alternative indices. On the other hand, the Pen World Table (PwT)[22] provides country-level indices of TFP at constant national prices - variable "rtfpna". To make our index comparable, we once again aggregate our data, but now to country-levels.

It is important to highlight that the methodology we have chosen to apply is completely different from the one PwT uses to derive their aggregate TFP indices, so there are no mandatory coincidences imposed between each pair of series. *A priori*, we cannot even expect or predict high positive correlations between the two alternative measures. Given this, the results we present throughout the next section are surprisingly encouraging.

1.4.2 Multi-Country Aggregate TFP Indices

We illustrate the comparisons between the series from PwT 8.1 and our indices through some selected country-level series displayed on Figure 1, in which annual TFP indices are denominated in constant national prices.

[21] Base year = 1995.

[22] We use the version 8.1 (Feenstra, R.C., Inklaar, R. and Timmer, M.P. (2015)).

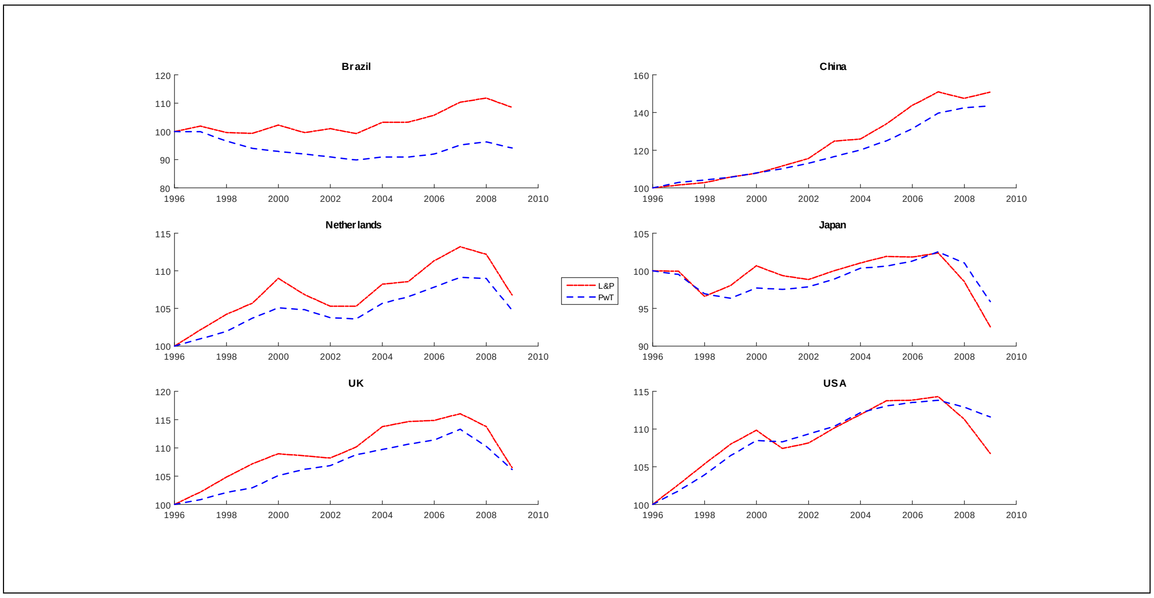

Figure 1.1: Country-level Aggregate TFP Index - Selected Countries

One can easily observe commonalities between most of the alternatively measured country-level TFP pairs; in almost all cases the behavior of both series is similar. A pattern worth noticing is that our measure, depicted in red on Figure 1, tends to assign higher values to annual TFP than PwT's series does. Other interesting feature is that both indices record a sharp decline of the total factor productivity for most countries in 2007, reflecting the subprime crisis.

For example, for China and Netherlands, the correlation coefficient between PwT's index and ours is of 0,99. Therefore, despite the fact that the latter is more volatile than the former, both seem to capture the same growth trends. Also, both indices record a remarkable and continuous increase of China's TFP. PwT registered an expansion of 43% on Chinese productivity while, according to our calculations, it has grown 51%.

It is also possible to trace a similar path for Japan productivity. Between 2002 and 2007, both series' values rise so that, in 2007, Japanese TFP is 2% higher than in 1996. From 2007 to 2009, PwT's series indicates a productivity decrease of 6,6 points, while ours computes a loss of 10 points.

In Appendix 2, we present aggregate TFP (index and level) for other regions and countries. Note that, since both sectoral and aggregate TFP are denominated in national currencies, we cannot perform cross-country comparisons of TFP in levels. Unfortunately, series of purchasing power parities at the disaggregation level we work with in this paper are not yet available.

The next two sections present sectoral productivity results. As it will be clear, some of our results are at odds with previous conclusions that have been drawn from labor productivity data, mostly because our framework enables us to quantify the influence of all inputs on productivity.

1.4.3 Multi-Country 3-Sector Growth Rates of TFP

To summarize our sectoral growth rate's results, the three following figures contrast each country's annualized growth rate of aggregate TFP - i.e. related to total economy's outcomes - with its annualized growth rate of sectoral TFP, respectively, on agriculture, industry and services. These compound annual growth rates represent the TFP growth observed for the period 1996-2009.

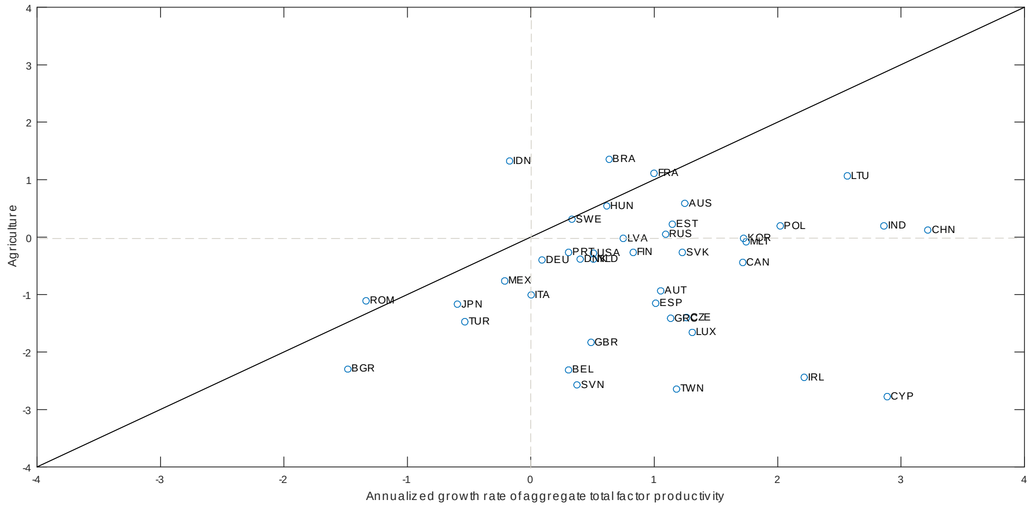

Figure 1.2: Annualized Growth Rates of TFP: Agriculture vs. Total Economy

We can note from Figure 2 that, although there has been some considerable dispersion in relative growth rates, only four countries experienced higher annualized growth rates of TFP in agriculture than in the respective economy aggregate, namely Brazil, France, Indonesia and Romania.

Sectoral and total rates have been almost coinciding in Sweden. Cyprus, which had one of the highest annualized growth rate of aggregate TFP, presented the lowest one in agriculture. Bulgaria was the country with the worst TFP growth performance over the period under analysis, responding for the lowest TFP growth rate in total economy and one of the lowest in agriculture.

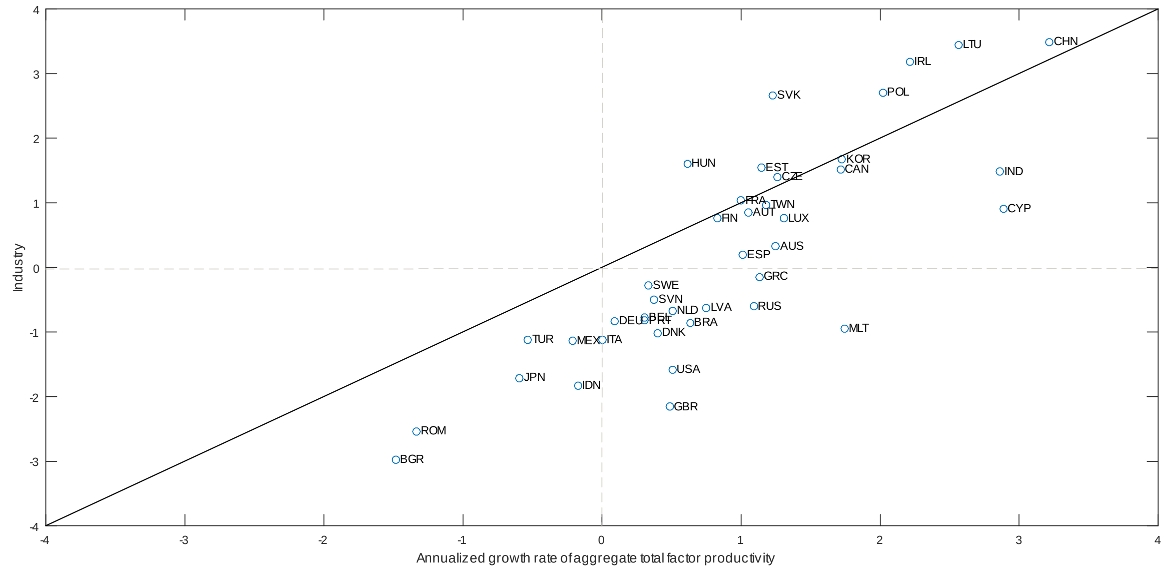

Figure 1.3: Annualized Growth Rates of TFP: Industry vs. Total Economy

Figure 3 plots the annualized growth rates of TFP in industry against the annualized growth rates of aggregate TFP. Industry's relative growth rates were far more concentrated than the agriculture ones but, once again, only a little number of countries had higher annualized growth rates of TFP in industry than in the respective economy aggregate: China, Czech Republic, Estonia, France, Hungary, Ireland, Lithuania, Poland and Slovakia.

The worst performance can again be assigned to Bulgaria and the highest growth rates both in industry and in total economy were observed in China.

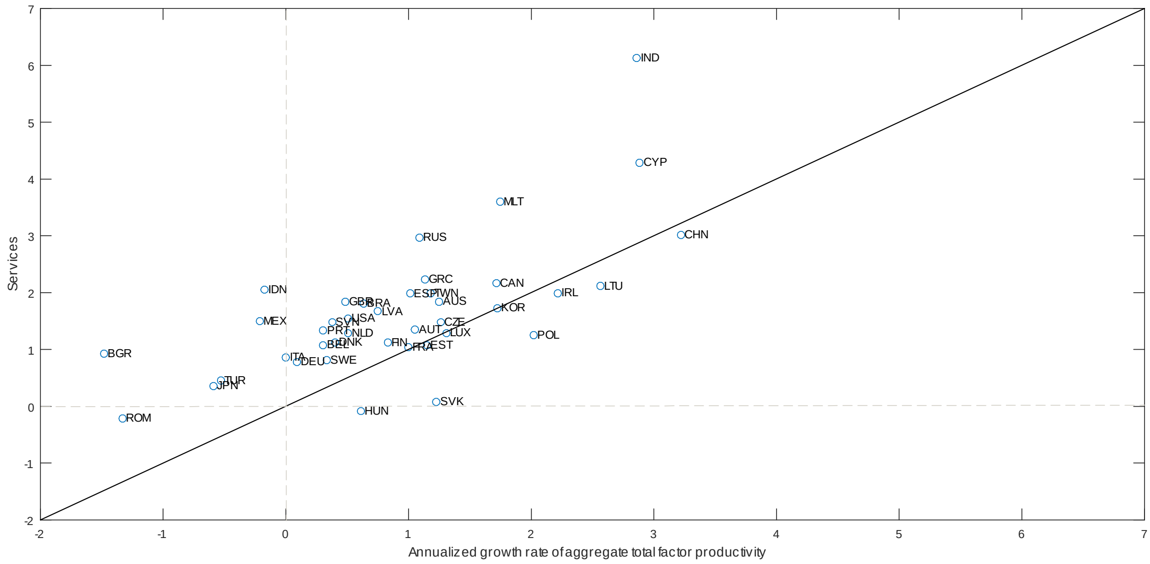

Figure 1.4: Annualized Growth Rates of TFP: Services vs. Total Economy

Lastly, figure 4 compares the annualized growth rates of TFP in services to the annualized growth rates of aggregate TFP. Contrary to what we observed in the two other sectors, the growth rates of TFP in services were usually higher than the aggregate growth rates for most of the countries.

The exceptions are China, Estonia, Hungary, Ireland, Lithuania, Luxembourg, Poland and Slovakia. Given this, note that all countries presenting annualized growth rates of TFP in industry higher than their aggregate growth rates also presented low relative growth rates in services.

1.4.4 Multi-Country 3-Sector TFP Levels

Since showing all 120 TFP level series we obtained from the aggregation in 3 sectors would be fairly counterproductive, in this section we outline some relevant sectoral stylized facts that can be observed from the multi-country 3-sector TFP level series.

First, Figures 5 and 6 show, for the years of 1996 and 2009 respectively and for all countries, the ratio between TFP levels in services and in industry.

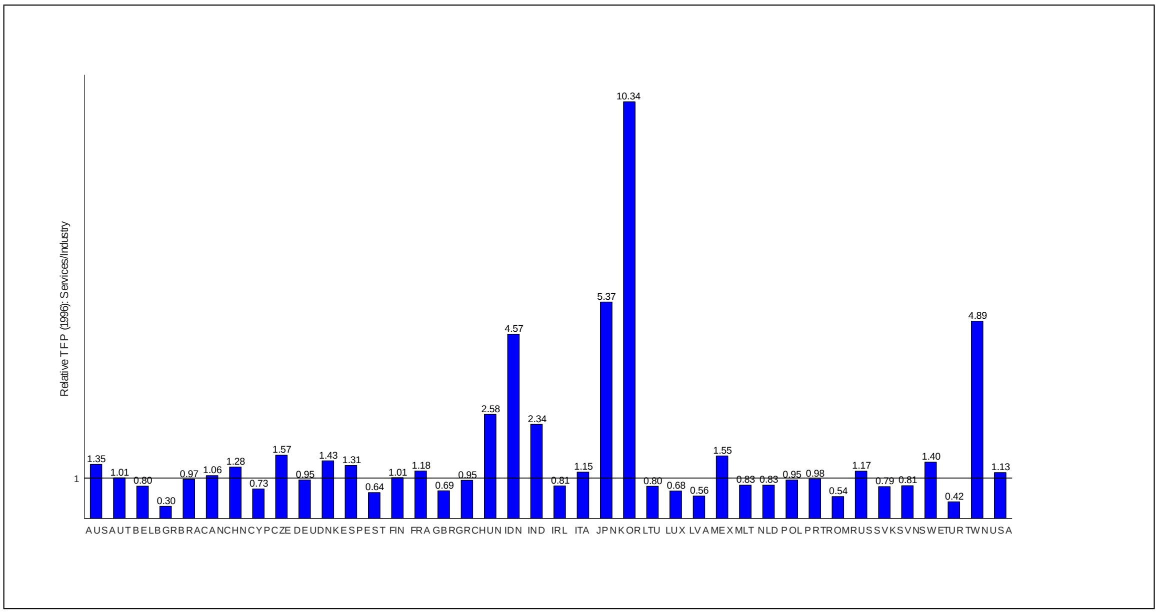

Figure 1.5: Relative Total Factor Productivity: Services-Industry Ratio for Forty Economies in 1996

In 1996, productivity in the services sector was higher than in industry for exactly half of the countries of our sample. For Asian countries such as Korea, Japan, Taiwan and Indonesia, TFP in services was already more than four times TFP in industry. On the other hand, for countries such as Brazil, Netherlands and the UK, this ratio was lower than one, indicating the opposite relation. For the USA, productivity in the services sector was only slightly higher than industry.

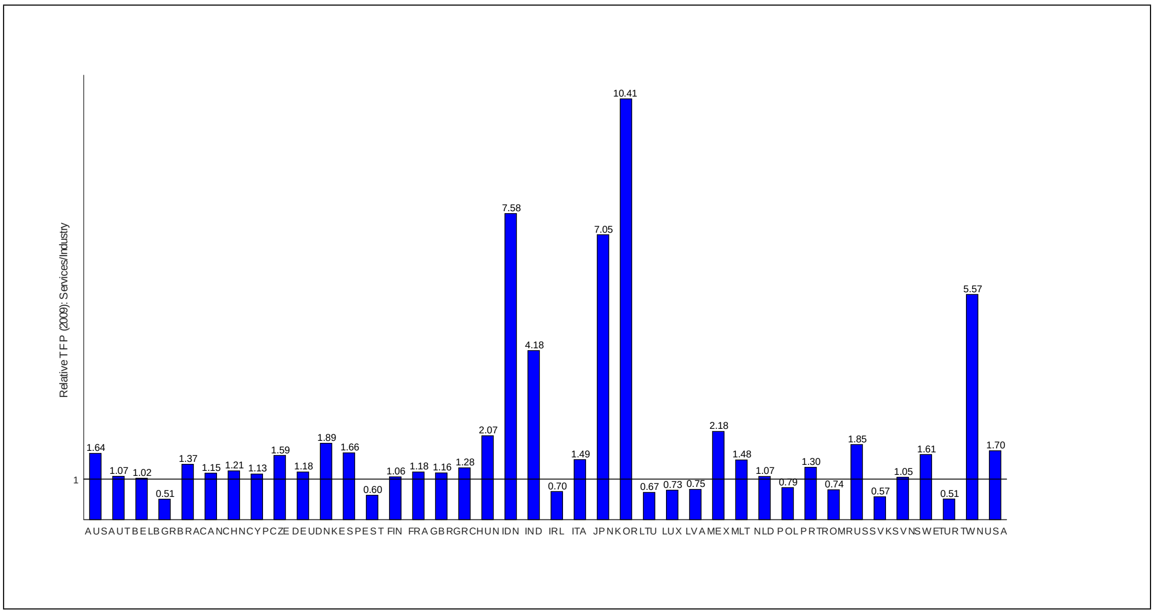

Figure 1.6: Relative Total Factor Productivity: Services-Industry Ratio for Forty Economies in 2009

In 2009, three-fourths of the countries presented productivity in services higher than in industry. In other words, over the 14 years under analysis, the productivity scenario has changed for 10 countries whose industry sector was relatively more productive than services in 1996.[23]

Moreover, for 33 out of the 40 countries analyzed, the services-industry ratios in 2009 were higher than in 1996, indicating that productivity in services has grown more than in industry over the years.[24] Actually, productivities in industry have actually dropped in twenty one countries of the sample, including Brazil, Germany, Denmark, Indonesia, Japan, Netherlands, the UK and the USA.[25] In contrast, productivity in services grown in almost all countries, only experiencing small declines in Hungary and Romania.

In sum, not only productivity in services was higher than in industry for most of the countries, but it also exhibited higher growth rates over the years. These findings are at odds with the conventional wisdom that productivity in industry is higher than in services (and that it grows more), which has been supported by some well-known results from the economic growth literature.[26]

These divergences can be attributed to the fact that these previous analysis were based on labor productivity comparisons between sectors (and countries), not on the contribution of all inputs.[27] In contrast, our framework enables us to quantify the influence of all inputs over

[23] These 10 countries are: Belgium, Brazil, Cyprus, Greece, Germany, Netherlands, Malta Portugal, Slovenia and the UK.

[24] The 7 countries in which the services-industry ratio was lower in 2009 than in 1996 are: China, Estonia, Hungary, Ireland, Lituania, Poland and Slovakia.

[25] The remaining countries are: Belgium, Bulgaria, Greece, Italia, Latvia, Malta, Mexico, Portugal, Romania, Russia, Slovenia, Sweden and Turkey.

[26] See, for example, the seminal work of Baumol (1967), Baumol et al. (1985) and the most recent contributions of Duarte and Restuccia (2010), McMillan and Rodrik (2011), Ferreira and Silva (2015) and Duarte and Restuccia (2015).

[27] For instance, Duarte and Restuccia (2010) observe that a country's aggregate productivity may face significant losses when, further along the process of structural transformation, the service sector becomes relatively more relevant than the industrial one. Such countries would "slow down, stagnate and decline"as the activities of the former are, on average, less efficient than of the latter. However, the importance of a proper investigation concerning the heterogeneity within the services sector has been emphasized by the related literature (see Baumol

productivity.

We now turn to the investigation of the previous section's six selected countries. This time, the focus will be on the evolution of their sectoral TFP (in levels). Once again, one must take into consideration the caveat that our sectoral series are not yet cross-country comparable. Also, note that each chart adopts a different scale. Figure 7 shows the 3-sector TFP for Brazil, China, Netherlands, Japan, UK and USA.

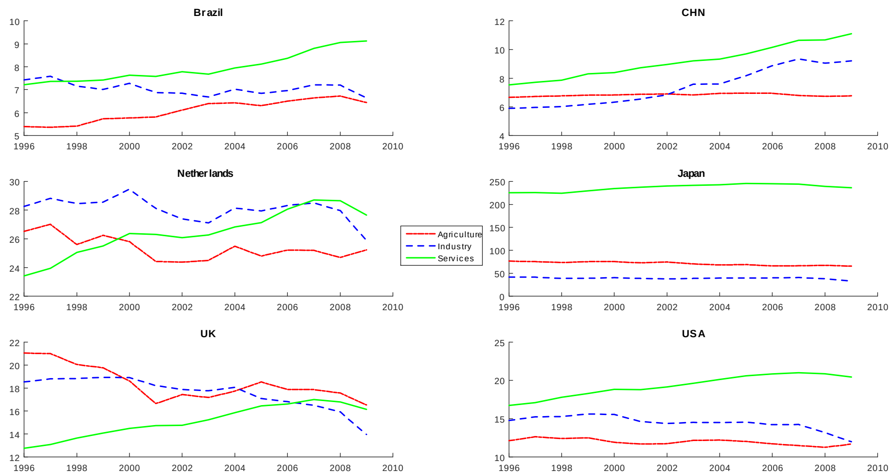

Figure 1.7: Multi-Country 3-Sector TFP Levels - Selected Countries

We have already stressed that Brazil was one of the few countries in our sample in which TFP in agriculture has grown at a higher annualized rate than TFP in total economy. Also, this country has been included on the large set of countries whose TFP in services has grown more than aggregate TFP. More specifically, from 1996 to 2009, Brazilian agriculture and services sectors have grown, respectively, 1,36% and 1,81% per year. On the other hand, over the same period of time, this country's industrial sector has shrink at a negative growth rate of 0,86% per year.

These opposite paths have accounted for a convergence between the productivities in agriculture and industry. Although TFP in industry was, in 1996, two points above TFP in agriculture, in 2009 this difference has almost vanished (being of only 0,21 points). Moreover, at the beginning of the period, the productivities in services and in industry were roughly the same. However, in the last year observed, productivity in services was already almost 40% higher than in industry.

Similarly to the convergence observed for industry and agriculture in Brasil, USA's productivities in these activities also experienced converging paths. While TFP in the former sector has declined at a rate of -1,58% per year, productivity in the latter has remained virtually unchanged over the whole period. Note also that productivity growth trends in the industrial and services sector are divergent, which is, once again, analogous to what we have observed for the

et al. (1985)). More recently, Duarte and Restuccia (2015) divide the service sector into two sub-categories, according to whether the relative prices (to the price of GDP) rise (traditional) or fall (non-traditional) with income. One of their findings indicates the existence of a strutural transformation within the service sector, in which development is associated with a reallocation of real expenditures from traditional to non-traditional services. Indeed, all of these conclusions are drawn from labor productivity measures.

brazilian series. USA's TFP in services has experienced an annual productivity increase of the same absolute magnitude of the fall of its industrial productivity (1,55% per year).

For Netherlands, Japan and the UK, productivities in services have grown at the positive rates of, respectively, 1,29%, 0,39% and 1,88% per year. In contrast, agriculture and industrial productivities in these countries experienced negative annualized growth rates in the same period. In Netherlands, while services' TFP in 2009 was 18% higher than in 1996, it has shrink almost 5% in agriculture and 9% in industry along the same period. In Japan, productivities in both agriculture and industry have faced falls of 1,17% and 1,71% per year, respectively. As a consequence, TFP in 2009 was 15% lower in agriculture and 20% lower in industry, relatively to their corresponding initial levels.

The annual downfall experienced by agriculture's productivity in the UK has been of the same magnitude of the increase of its service's productivity. As a result, there is a clear convergence between the two series: at the beginning of the analysis, TFP in agriculture was 65% higher than in services but, in the last observed year, this difference was of only 3%. In constrast, TFP in industry in 2009 was only three-quarters of the level observed in 1996. Such a sharp decrease consequently converted industry into the less productive sector of this economy.

Lastly, both Chinese industry and services TFP have expanded, respectively, at 3,49% and 3,02% per year, resulting in TFP levels in 2009 that were 56% higher than its initial value in industry and 47% higher in services. TFP in agriculture, however, have expanded relatively less than in the two other sectors, but we also observe a positive growth rate of 1,6% per year.

In summary, TFP in services has grown in all six countries under analysis. In contrast, except for China (whose TFP growth rates were positive for the three sectors), industry has experienced significant productivity losses over the period, which accounted for a convergence towards TFP in agriculture, the less efficient sector, specially in Brazil, Netherlands and the USA.

Note also that, in countries where TFP in services was already the highest at the beginning of the series, this sector has still remained as the most efficient one (see China's, Japan's and the USA's series). On the other hand, in Brazil and Netherlands, TFP's increase in services was high enough to turn this sector into the most efficient of these economies, and such pattern seems to be also followed by the UK's series.

Therefore, these results indicate that most of the aggregate TFP growth reported in the previous sections can be assigned to technological improvements in the services sector. In Appendix 3, we provide the 3-sector TFP levels for all countries, put together according to the mains trends of their sectoral series. One can see that this pattern repeats itself for a large number of economies.

1.4.5 Multi-Country 35-Activities TFP Levels

In this section, we aim to identify the disaggregate activities that were directly responsible for good or bad productivity performances in each of the three sectors and, therefore, in the country-level aggregate total factor productivities. The following figures present series for those economic activities in which productivities were among the five highest and five lowest in 2009. When these activities do not coincide with the ones that displayed highest annualized growth rates over the period, the latter are also included in the analysis.

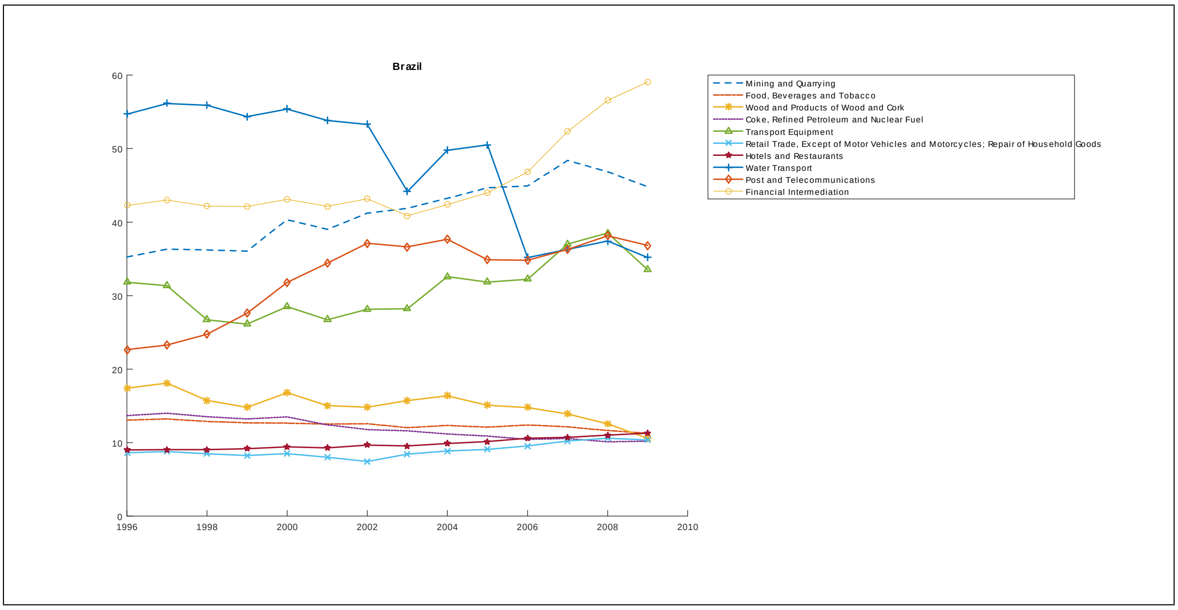

Figure 1.8: TFP Level Series: Brazil - Selected Activities

In Brazil (Figures 8 and 9) the great performance registered for the services sector was due to the high annual growth rates of "*Financial Intermediation*" (2,61% per year) and "*Post and Telecommunications*" (3,81% per year). Those activities also performed relatively well in 2009, reaching, respectively, the second and the fourth highest productivities of the economy.

The activity with the highest productivity in 2009 was, nevertheless, "*Real Estate Activities*". We show this series in a separate figure not only because of scale issues, but mostly due to the fact that the domestic output accounted for this activity - which are at the basis of our TFP results - includes the payment of rents, whose values are usually high. Therefore, TFP levels for this activity - in countries that adopt such accounting methodology - are likely influenced by an upward bias caused by value added distortions.

Other three sectors deserve attention, namely "*Mining and Quarrying*", "*Water Transport*" and "*Transport Equipment*", for being among the highest productivity activities in 2009. It is important to emphasize that productivity in "*Water Transport*" suffered a sharp fall, as it was the most productive activity in 1996, but lost three positions over the period, reflecting a high negative annualized growth rate (-3,34% per year).

At the other end, "*Coke, Refined Petroleum and Nuclear Fuel*"was the activity with lowest TFP in 2009, closely followed by "*Retail Trade, Except of Motor Vehicles and Motorcycles, Repair of Household Goods*" and "*Wood and Products of Wood and Cork*". The latter was also the activity with the highest productivity losses over the period (-3,76% per year). Lastly, *"Food, Beverages and Tobacco"*and *"Hotels and Restaurants"* also presented a poor relative productivity performance.

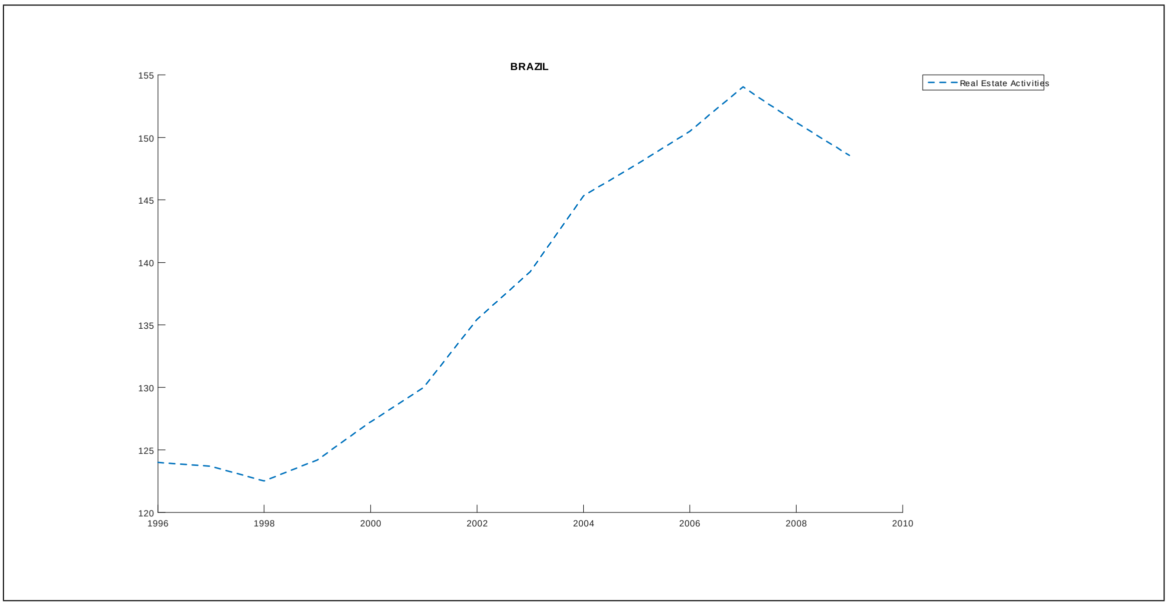

Figure 1.9: TFP Level Series: Brazil - Real Estate Activities

The extraordinary performances of industry and services and China (Figure 10) were respectively guided by the activities under "*Electrical and Optical Equipment*" (annualized growth rate of 8,32% per year) and "*Water Transport*" (10,04% increase per year).

It is possible to observe once again the high - and likely biased, as in Brazil's case - productivities in *Real Estate Activities*. However, other four activities from the services sector were also able to obtain remarkable relative productivities in 2009: "*Financial Intermediation*", "*Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles*", "*Post and Telecommunications*" and "*Renting of M&Eq and Other Business Activities*".

On the other hand, Chinese "*Agriculture, Hunting, Forestry and Fishing*" was the most disappointing TFP result, for being almost stagnant at the lowest TFP levels in every year of the sample.

Other poor productivity performances in 2009 - although with some positive growth recorded for the whole period - can be observed in some industrial activities - "*Textiles and Textile Products*", "*Coke, Refined Petroleum and Nuclear Fuel*" and "*Food, Beverages and Tobacco*" - and in "*Hotels and Restaurants*", amongst services activities.

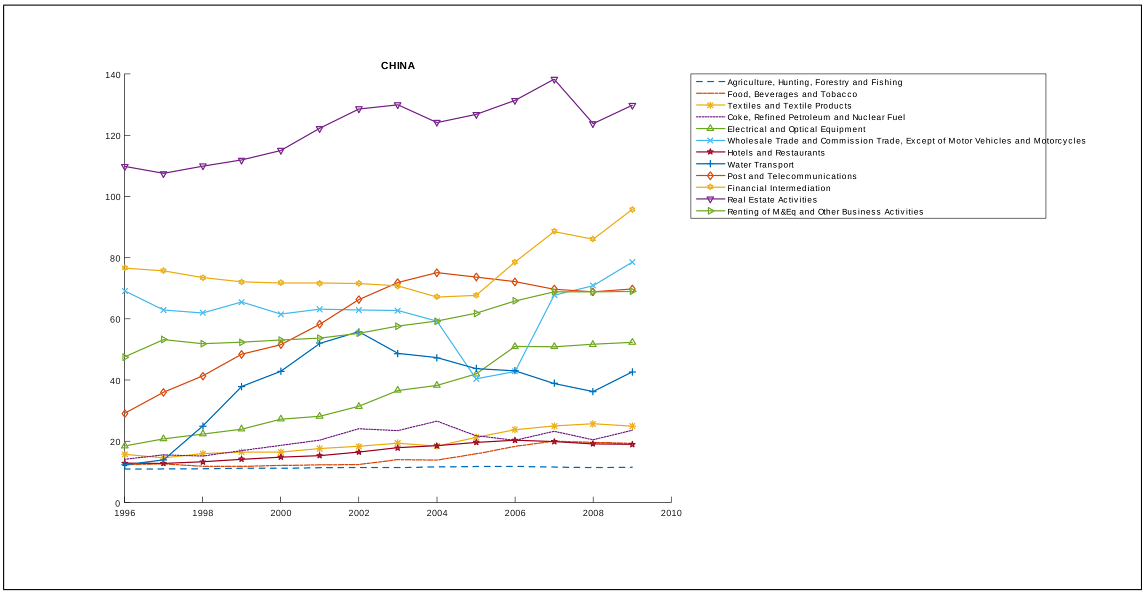

Figure 1.10: TFP Level Series: China - Selected Activities

The positive productivity growth of services in Japan (Figure 11) was mostly due to the TFP expansion in "*Water Transport*"(with an annualized growth rate of 3,97% per year) and "*Renting of M&Eq and Other Business Activities*" (3,76% per year).

Despite of its low annual growth rates, "*Education*" was the activity that achieved the highest levels throughout the entire period. Additionally, we must highlight the excellent performances of "*Public Admin and Defense; Compulsory Social Security*", "*Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies*", "*Renting of M&Eq and Other Business Activities*" and "*Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods*".

Therefore, the five highest productivities in Japan were computed in activities belonging to the services sector. It was an expected result, since both agriculture and industrial productivities have presented negative annualized growth rates. Actually, the only activity not assigned to the services sector that presented a positive growth rate was "*Electrical and Optical Equipment*", an industrial activity.

However, the worst five TFP results in 2009 were also categories of industrial activities: *"Transport Equipment", "Basic Metals and Fabricated Metal", "Coke, Refined Petroleum, and Nuclear Fuel"*, "*Chemicals and Chemical Products*" and "*Food, Beverages and Tobacco*".

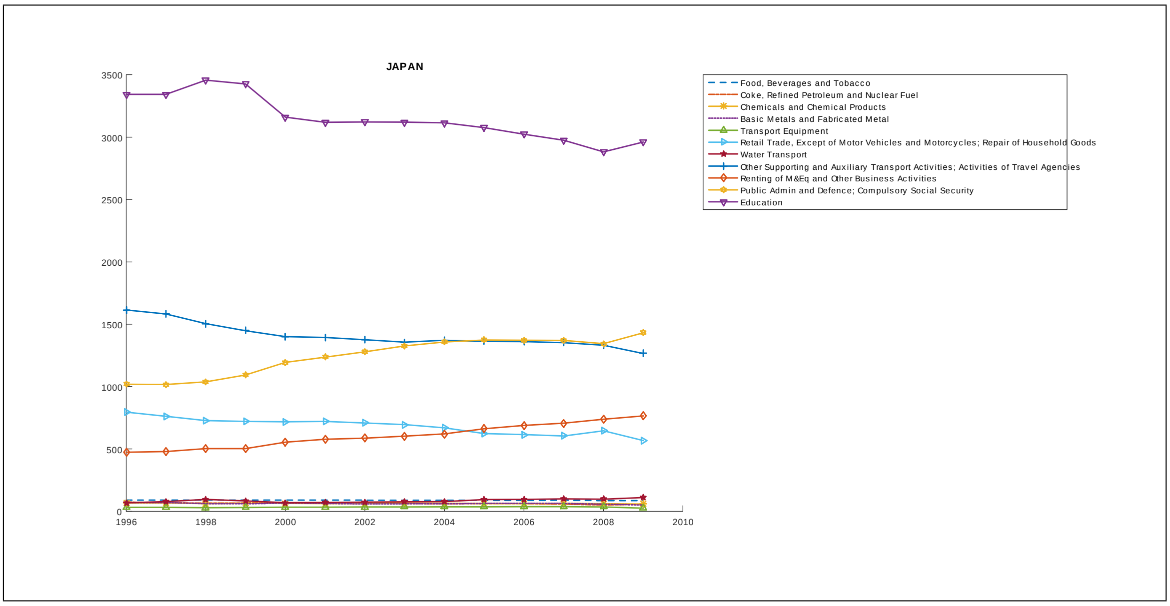

Figure 1.11: TFP Level Series: Japan - Selected Activities

In Netherlands (Figure 12), "*Mining and Quarrying*" experienced the highest TFP for the whole period under analysis. We present this series in a separate figure (Figure 13) only because of the scale.

Note in figure 12 that among the subsequent top four productivity activities, half belong to the services sector - "*Post and Telecommunications*" and "*Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles*"and the other half to the industrial sector - "*Chemicals and Chemical Products*" and "*Machinery, Nec*". Moreover, except for the activities assign to "*Coke, Refined Petroleum and Nuclear Fuel*", only in these two industrial activities it was also possible to observe positive annualized growth rates.

However, as once again expected, the two highest growth rates were computed for subgroups of services activities: "*Post and Telecommunications*"(4,90% per year) and "*Health and Social Work*"(2,47% per year).

At the other end, the yet mentioned *"Coke, Refined Petroleum and Nuclear Fuel"* experienced the worse productivity performance in every year of the sample, similarly to "*Private Households with Employed Persons*" at the services sector. "*Hotels and Restaurants*" and "*Water Transport*" also presented poor productivity performance. In the latter, TFP can was highly volatile, and the sharp fall observable in 2008 assigned to this activity the second worst productivity level in 2009.

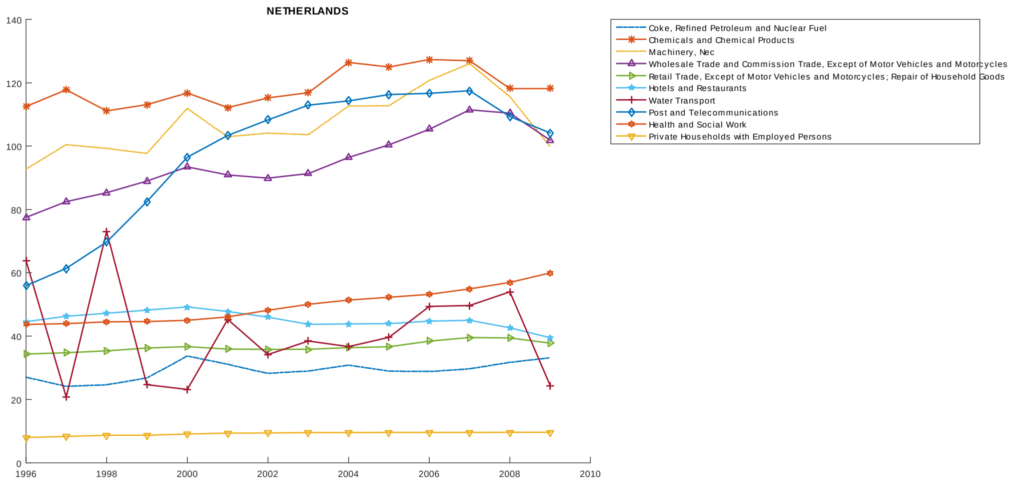

Figure 1.12: TFP Level Series: Netherlands - Selected Activities

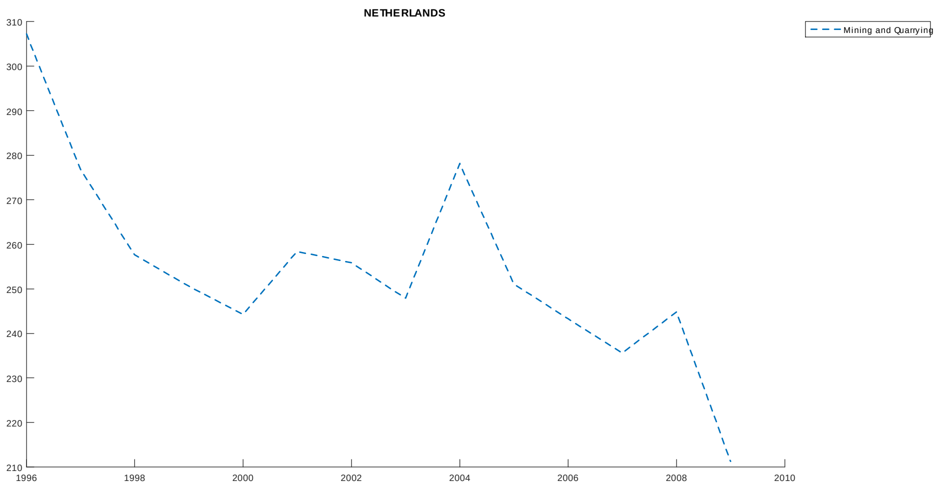

Figure 1.13: TFP Level Series: Netherlands - Mining and Quarrying

In the UK (Figure 14), the prominent productivity in services was mainly influenced by the TFPs in "*Manufacturing, Nec; Recycling*", "*Post and Telecommunications Sale*"and "*Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel*". Nevertheless, the activities with the highest annualized growth rates were "*Health and Social Work*"(3,52% per year) and "*Renting of M&Eq and Other Business Activities*"(3,62% per year), both as well assigned to the service sector.

Even though industry's productivity has fallen over the period, two of its activities still presented relatively high TFPs in 2009: "*Rubber and Plastics*"and "*Mining and Quarrying*". However, productivities in "*Electricity, Gas and Water Supply*"and "*Coke, Refined Petroleum*

and Nuclear Fuel"were among the three lowest throughout the economy, presenting negative growth rates.

But the evolution of the TFP in "*Water Transport*" was, by far, the worse of all. Besides presenting the most negative annualized growth rates (-7,87% per year), its levels in 2009 were also the lowest, surpassing "*Private Households with Employed Persons*".

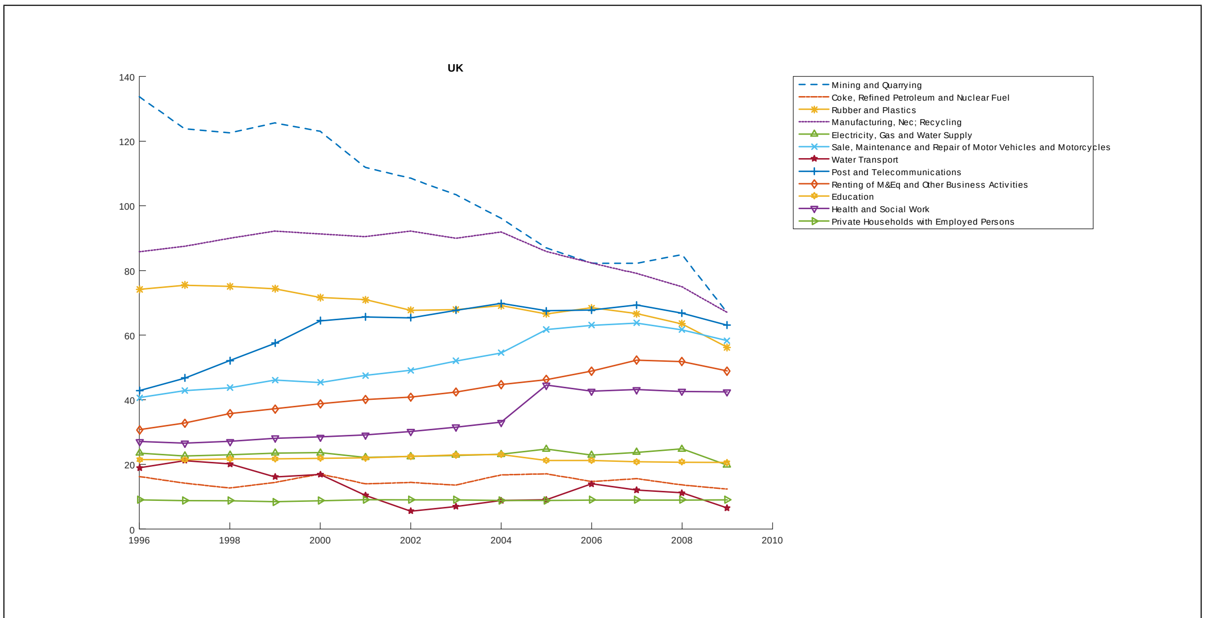

Figure 1.14: TFP Level Series: the UK - Selected Activities

At last, we analyze the USA (Figure 15) productivity's scenario. First, note that the high annualized growth rate of productivity in services was primarily driven by *"Renting of M&Eq and Other Business Activities"* (2,30% per year) and *"Financial Intermediation"*(2,37% per year). Actually, from the highest five TPF performances, four were subgroups of services - "*Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles*", "*Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel*", "*Post and Telecommunications*"and "*Public Admin and Defence; Compulsory Social Security*- and one of industry, "*Electrical and Optical Equipment*".

However, productivity in industry was negatively influenced by the extremely low TFP levels in "*Food, Beverages and Tobacco*", "*Coke, Refined Petroleum and Nuclear Fuel*"and, specially, in "*Textiles and Textile Products*", which was the activity that obtained the lowest growth along the period (-7,92% per year) as well.

Other activities belonging to the service sector did not perform well, namely "*Water Transport*"and "*Private Households with Employed Persons*", the latter being also responsible for the lowest TFP levels in every year of the sample span.

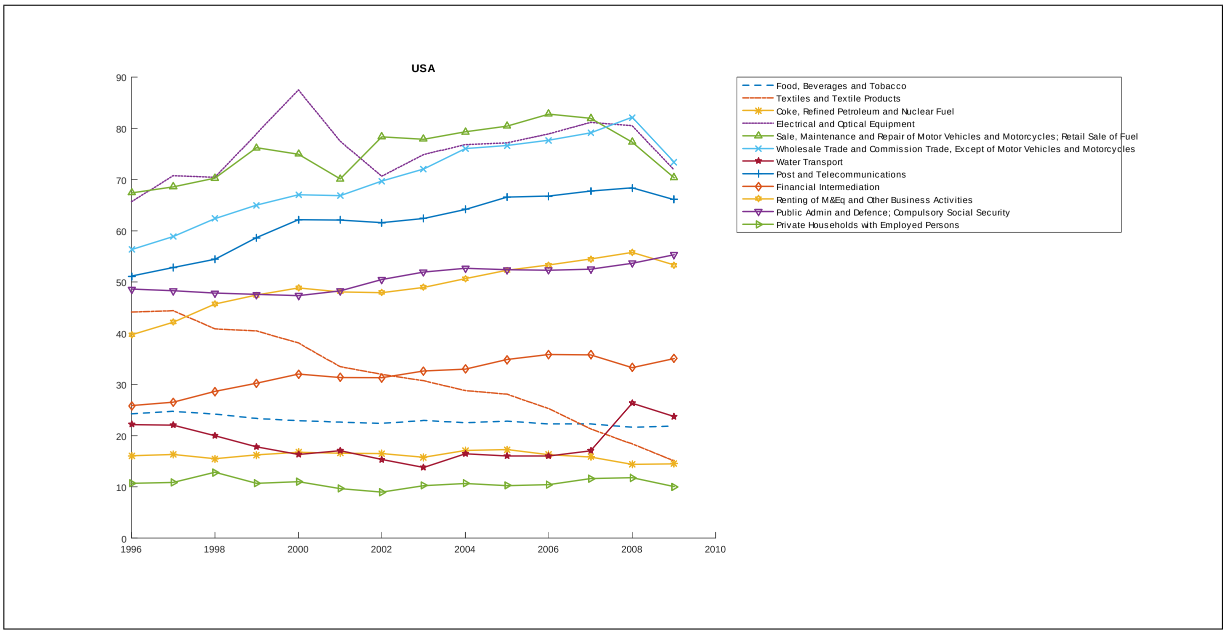

Figure 1.15: TFP Level Series: the USA - Selected Activities

1.5 Conclusions

One of the greatest challenges faced by the macroeconomic literature is to identify the reasons why a reduced group of countries holds the majority of the world's wealth. Indeed, the primary importance of cross-country differences on labor productivity and total factor productivity (TFP) in explaining large shares of differences in income has already been established by a great number of studies in the field.

There have been some severe obstacles to this agenda, such as the absence of comprehensive sectoral data sources. However, the recent development and release of The World Input-Output Database (WIOD) - which includes the World Input-Output Tables (WIOT) and the Socio Economic Accounts (SEA) - may help filling this important gap.

A remarkable limitation for quantitative sectoral productivity studies is the fact that, up to the present date, there are no activity-level total factor productivity series available, even though theory says that total factor productivity is the one of the main drivers of cross-country growth.

In this paper, we have offered an alternative analytical setup for estimating sectoral TFPs. We employed the seminal contribution of Long and Plosser (1983) to the real business cycle literature to construct total factor productivity (TFP) measures that are multi-country and multi-sector. This is a novel approach, since the previous literature has used only labor-productivity measures to discuss long-run growth.

By combining worldwide data from the WIOD and the input-output linkages of the proposed setup, we were able to calculate sectoral total factor productivity for a set of countries that respond to more than 85% of world's GDPs. The main products of this exercise are 1400 series (for 35 activities and 40 countries) of multi-country sectoral TFP levels and indices of multi-country sectoral TFP, both sets denominated in constant national currencies.

We then aggregated data to construct country-level and 3-sector indices and level series. This allowed us to compare our results to the Penn World Table indices and to gain some intuition related to the main growth trends of these series and of the sectoral ones.

However, one important caveat was imposed by the available sectoral data we used to construct our series. Since sectoral and aggregate TFP levels are denominated in national currencies

and, unfortunately, data on purchasing power parities at the disaggregation level we needed is not yet available, it was not yet possible for us to perform cross-country comparisons. Nevertheless, we were able to extract some unprecedented insights from the sectoral series we have to date.

For instance, in 2009, from the 40 countries covered by our database, 33 presented services-industry productivity ratios that were higher than the ones observed thirteen years earlier. This result indicates that productivities in services have, at least, grown more than in industry over the years. In fact, productivities in industry have actually dropped in 21 countries of the sample, including Brazil, Germany, Denmark, Indonesia, Japan, Netherlands, the UK and the USA.

Another result has supported this trend. In 2009, only 1/4 of the countries presented productivity in industry higher than in the services sector, meaning that, along the fourteen years under analysis, productivity in services has become higher than in industry in ten countries of the sample, for whom the inverse relation used to be observed.

Regarding the sectoral annualized growth rates, we have shown that only 4 countries[28] have experienced higher annualized growth rates of TFP in agriculture than in the respective economy aggregate. Also, only in 9 countries[29] the annualized growth rates of TFP in industry have been higher than in the respective economy aggregate. In contrast, the growth rates of TFP in services have been higher than the aggregate growth rates for most of the countries[30].

For a considerably large number of countries, an investigation on the 3-sector TFPs indicate that most of the aggregate TFP growth reported can be assigned to technological improvements in the service sector. That is, not only productivity in services was higher than in industry for most of the countries, but it also exhibited higher growth rates over the years.

In fact, these results are at odds with some widely known conclusions, which have been drawn from labor productivity data by previous work in the field. One possible reason for these divergences lies in the fact that our framework enables us to to quantify the influence of all inputs on total factor productivities. Therefore, by constructing this new dataset on actual total factor productivities, we aim to encourage a wide range of new disaggregate sectoral analysis for a large number of countries.

[28] Brazil, France, Indonesia and Romania.

[29] China, Czech Republic, Estonia, France, Hungary, Ireland, Lithuania, Poland and Slovakia.

[30] The exceptions were China, Estonia, Hungary, Ireland, Lithuania, Luxembourg, Poland and Slovakia.

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Appendix 1

The individual's intertemporal optimization problem consists in maximizing the present value of the discounted sum of expected utilities, which is given by:

$$E\left(U|S_t\right)=E\left[\sum_{s=t}^{\infty}\beta^{s-t}u(C_s,Z_s)|S_t\right] \tag{1A}$$

where the one-period utility, $u(C_t, Z_t)$ is of the form:

$$u(C_s,Z_s)=\theta_0\ln Z_s+\sum_{i-1}^{N}\theta_i\ln C_{i,s}, \qquad \theta_0>0,\ \theta_i\geq 0, i=0,1,\ldots,N \tag{2A}$$

subject to the production possibilities constraint and to the two resource constraints:

$$Y_{i,t+1}=\lambda_{i,t+1}L_{i,t}^{b_i}\prod_{j=1}^{N}X_{ij,t}^{aij}, \tag{3A}$$

where $b_i\geq 0$, $i=1,\ldots,N$, $a_{ij}\geq 0$, $i,j=1,\ldots,N$ and $\sum_{j=1}^{N}a_{ij}+b_i=1$, $i=1,\ldots,N$,

$$Z_t+\sum_{i=1}^{N}L_{i,t}=H, \tag{4A}$$

$$C_{j,t}+\sum_{i=1}^{N}X_{ij,t}=Y_{j,t}, \qquad j=1,2,\ldots,N. \tag{5A}$$

The choice of a log-linear utility function guarantees that if the welfare function $V(S_t)$ is defined as the constrained maximum of $E\left(U|S_t\right)$, then V and the optimal allocation plan are jointly the solution to

$$V(S_t)=\max_{d_t}\left\{u(C_t,Z_t)+\beta E\left[V\left(S_{t+1}\right)|S_t\right]\right\} \tag{6A}$$

where d_t stands for all current decision variables at time t: $L_{i,t}$, Z_t, $C_{i,t}$, $X_{ij,t}$, $i,j=1,\ldots,N$.

Long and Plosser (1983) provided a solution to this functional equation of a form given by:

$$V(S_t)=\sum_{i=1}^{N}\gamma_i\ln Y_{i,t}+J(\lambda_t)+K \tag{7A}$$

where

$$\begin{aligned}\gamma_j &= \theta_j+\beta\sum_{i=1}^{N}\gamma_i a_{ij},\ j=1,2,\ldots,N,\\ J(\lambda_t) &= \beta E\left[\sum_{i=1}^{N}\gamma_i\ln\lambda_{i,t+1}+J(\lambda_{t+1})|\lambda_t\right],\end{aligned}$$

and K is a constant that only depends on preference and production parameters, but not on state variables, Y_t or λ_t.

One can verify the validity of this solution by assuming that V is given by (7A) and then maximizing on the right-hand side of (6A) with respect to time t consumption and input decisions. If the maximum on the right-hand side of (6A), as a function of S_t, is given by $V(S_t)$ as defined by (7A), then we have got a valid solution to the functional equation.

Substituting (7A) evaluated at time $t+1$ and (2A) on the right-hand side of (6A), we have the following problem:

$$\max_{d_t}\left\{\theta_0 \ln Z_t + \sum_{i=1}^{N}\theta_i \ln C_{i,t} + \beta E\left[\sum_{i=1}^{N}\gamma_i \ln Y_{i,t+1} + J(\lambda_{t+1}) + K \mid S_t\right]\right\} \tag{8A}$$

s.t. (3A),(4A) and (5A).

Substituting (3A) into (8A):

$$\max_{d_t}\left\{\theta_0 \ln Z_t + \sum_{i=1}^{N}\theta_i \ln C_{i,t} + \beta E\left[\sum_{i=1}^{N}\gamma_i \ln\left(\lambda_{i,t+1} L_{i,t}^{b_i}\prod_{j=1}^{N} X_{ij,t}^{aij}\right) + J(\lambda_{t+1}) + K \mid S_t\right]\right\} \tag{9A}$$

s.t. (4A) and (5A).

Rearranging (9A):

$$\begin{aligned}\theta_0 \ln Z_t + \sum_{i=1}^{N}\theta_i \ln C_{i,t} + \beta E\left[\sum_{i=1}^{N}\gamma_i \ln \lambda_{i,t+1} \mid S_t\right] + \beta\sum_{i=1}^{N}\gamma_i b_i \ln L_{i,t} + \\ +\beta\sum_{i=1}^{N}\gamma_i\sum_{j=1}^{N}a_{ij}\ln X_{ij,t} + \beta E\left[J(\lambda_{t+1}) \mid S_t\right] + \beta K\end{aligned} \tag{10A}$$

Hence the Lagrangian for this static optimization problem is defined by:

$$\begin{aligned}L(Z_t, C_{i,t}, L_{i,t}, X_{ij,t}, \delta, \mu_j) &= \theta_0 \ln Z_t + \sum_{i=1}^{N}\theta_i \ln C_{i,t} + \beta\sum_{i=1}^{N}\gamma_i b_i \ln L_{i,t} + \beta\sum_{i=1}^{N}\gamma_i\sum_{j=1}^{N}a_{ij}\ln X_{ij,t} + \\ &+\beta E\left[\sum_{i=1}^{N}\gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1}) \mid S_t\right] + \beta K + \\ &+\sum_{j=1}^{N}\mu_j\left(Y_{j,t} - C_{j,t} - \sum_{i=1}^{N}X_{ij,t}\right) + \delta\left(H - Z_t - \sum_{i=1}^{N}L_{i,t}\right)\end{aligned} \tag{11A}$$

The first order conditions - which are also sufficient - for this problem, are:

$$C_{i,t} = \frac{\theta_i}{\mu_i}, \qquad i = 1, ..., N \tag{12A}$$

$$X_{ij,t} = \frac{\beta\gamma_i a_{ij}}{\mu_j}, \qquad i, j = 1, ..., N \tag{13A}$$

$$Z_t = Z = \frac{\theta_0}{\delta} \tag{14A}$$

$$L_{i,t} = \frac{\beta\gamma_i b_i}{\delta}, \qquad i = 1, ..., N \tag{15A}$$

where $\gamma_j = \theta_j + \beta\sum_{i=1}^{N}\gamma_i a_{ij}$, $j = 1, \ldots, N$ and δ and μ_i are the lagrange multipliers associated with (4A) and (5A) respectively.

Substituting (12A) and (13A) into (5A):

$$\mu_j = \frac{\gamma_j}{Y_{j,t}}, \qquad j = 1, ..., N \tag{16A}$$

Also, substituting (14A) and (15A) into (4A) we obtain:

$$\delta = \frac{\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j}{H} \tag{17A}$$

And finally substituting the lagrange multipliers into the equations (12A) - (15A), we obtain the following optimal decision rules:

$$C^*_{i,t} = \left(\frac{\theta_i}{\gamma_i}\right) Y_{i,t}, \qquad i = 1, 2, \ldots, N \tag{18A}$$

$$X^*_{ij,t} = \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j}\right) Y_{j,t}, \qquad i, j = 1, 2, \ldots, N \tag{19A}$$

$$Z^*_t = \theta_0 \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i\right)^{-1} H, \tag{20A}$$

$$L^*_{i,t} = \beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j\right)^{-1} H, \qquad i = 1, 2, \ldots, N \tag{21A}$$

Now, to verify that the maximum on the right-hand side of (6A), as a function of S_t, is indeed given by $V(S_t)$ as defined by (7A), we first substitute the decision rules (18A) - (21A) into the the right-hand side of the functional (6A):

$$\theta_0 \ln \left[\theta_0 \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i\right)^{-1} H\right] + \sum_{i=1}^{N} \theta_i \ln \left[\left(\frac{\theta_i}{\gamma_i}\right) Y_{i,t}\right] + \beta E \left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} \mid S_t\right] +$$
$$+\beta \sum_{i=1}^{N} \gamma_i b_i \ln \left[\beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j\right)^{-1} H\right] + \beta \sum_{i=1}^{N} \gamma_i \sum_{j=1}^{N} a_{ij} \ln \left[\left(\frac{\beta \gamma_i a_{ij}}{\gamma_j}\right) Y_{j,t}\right] +$$
$$+\beta E\left[J(\lambda_{t+1}) \mid S_t\right] + \beta K$$

Then, after some algebric manipulation, the right-hand side of (6A) becomes:

$$\left(\sum_{i-1}^{N} \theta_i + \beta \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_i a_{ij}\right) \ln Y_{i,t} + \beta E \left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1}) \mid \lambda_t\right] +$$
$$+\theta_0 \ln \theta_0 + \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i\right) \ln \left[\left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i\right)^{-1} H\right] + \sum_{i=1}^{N} \theta_i \ln \left(\frac{\theta_i}{\gamma_i}\right) +$$
$$+\beta \sum_{i=1}^{N} \gamma_i b_i \ln (\beta \gamma_i b_i) + \beta \sum_{i=1}^{N} \gamma_i \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j}\right) + \beta K$$

Moreover, the left-hand side must be equal to the right-hand side of the funcional, hence:

$$\begin{aligned} V(S_t) &= \sum_{i=1}^{N} \gamma_i \ln Y_{i,t} + J(\lambda_t) + K = \\ &= \left(\sum_{i=1}^{N} \theta_i + \beta \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_i a_{ij} \right) \ln Y_{i,t} + \beta E \left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1}) \mid \lambda_t \right] + \\ &\quad + \theta_0 \ln \theta_0 + \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i \right) \ln \left[\left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i \right)^{-1} H \right] + \sum_{i-1}^{N} \theta_i \ln \left(\frac{\theta_i}{\gamma_i} \right) + \\ &\quad + \beta \sum_{i=1}^{N} \gamma_i b_i \ln (\beta \gamma_i b_i) + \beta \sum_{i=1}^{N} \gamma_i \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right) + \beta K \end{aligned}$$

Which gives us the following correspondences:

$$\begin{aligned} \sum_{i=1}^{N} \gamma_i \ln Y_{i,t} &= \left(\sum_{i=1}^{N} \theta_i + \beta \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_i a_{ij} \right) \ln Y_{i,t} \Leftrightarrow \\ &\Leftrightarrow \sum_{j=1}^{N} \gamma_j \ln Y_{j,t} = \left(\sum_{j=1}^{N} \theta_j + \beta \sum_{j=1}^{N} \sum_{i=1}^{N} \gamma_i a_{ij} \right) \ln Y_{j,t} \Leftrightarrow \\ &\Leftrightarrow \sum_{j=1}^{N} \gamma_j \ln Y_{j,t} = \sum_{j=1}^{N} \left(\theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij} \right) \ln Y_{j,t} \Leftrightarrow \\ &\Leftrightarrow \gamma_j = \theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij}, \qquad j = 1, 2, \ldots, N, \\ J(\lambda_t) &= \beta E \left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1}) | \lambda_t \right], \\ K &= \frac{1}{1-\beta} \left\{ \theta_0 \ln \theta_0 + \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i \right) \ln \left[\left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i \right)^{-1} H \right] \right\} + \\ &\quad + \frac{1}{1-\beta} \left\{ \sum_{i-1}^{N} \theta_i \ln \left(\frac{\theta_i}{\gamma_i} \right) + \beta \sum_{i=1}^{N} \gamma_i b_i \ln (\beta \gamma_i b_i) + \beta \sum_{i=1}^{N} \gamma_i \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right) \right\} \end{aligned}$$

Therefore, the value function proposed by Long and Plosser (1983) is a valid solution to the optimization problem.

Appendix 2

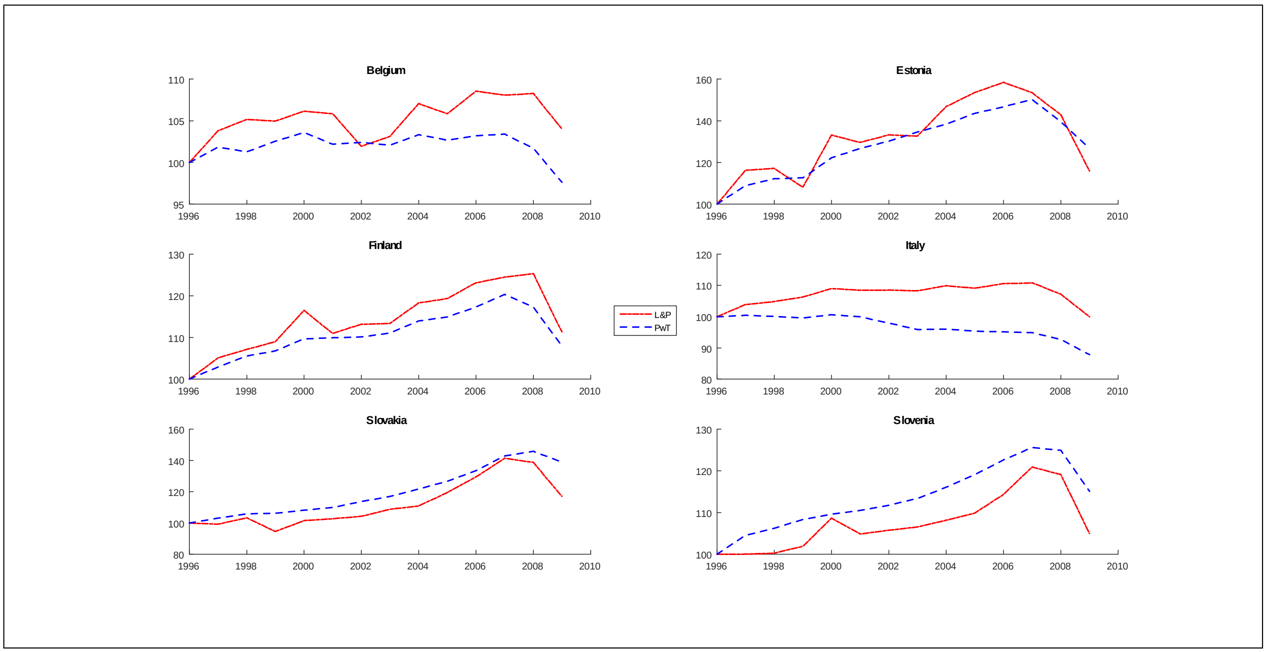


Figure 1.16: Country-level Aggregate TFP Index - Euro-Zone Selected Countries

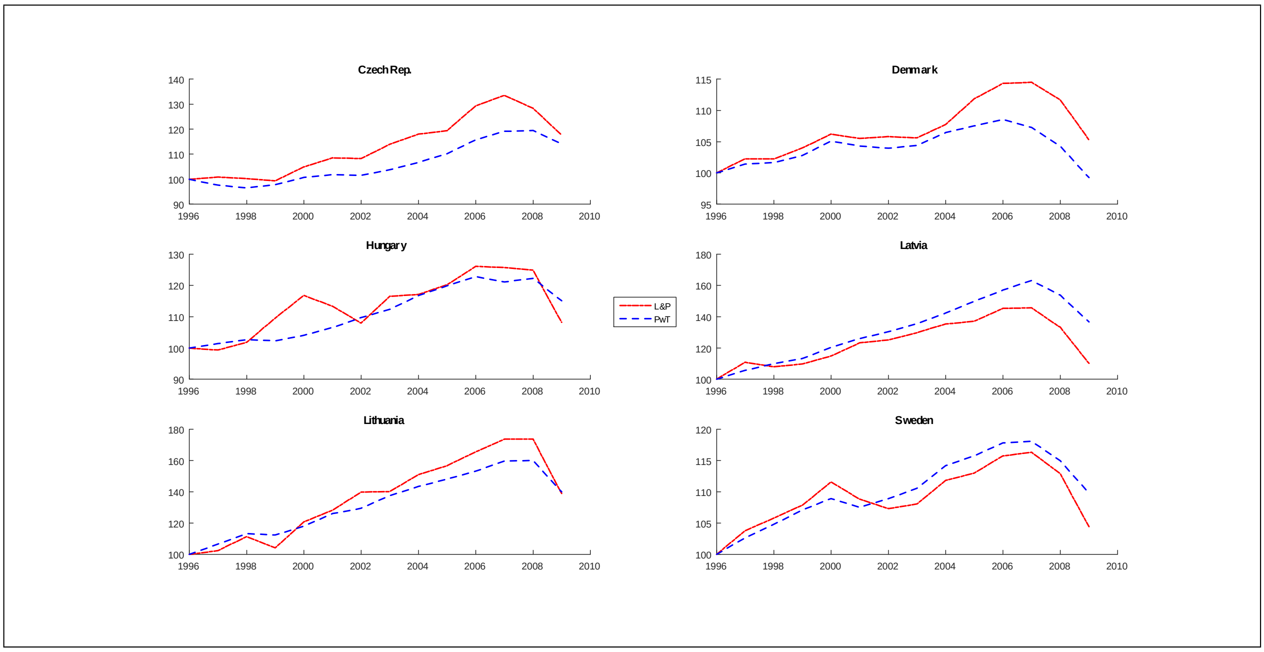


Figure 1.17: Country-level Aggregate TFP Index - Non-Euro EU Selected Countries

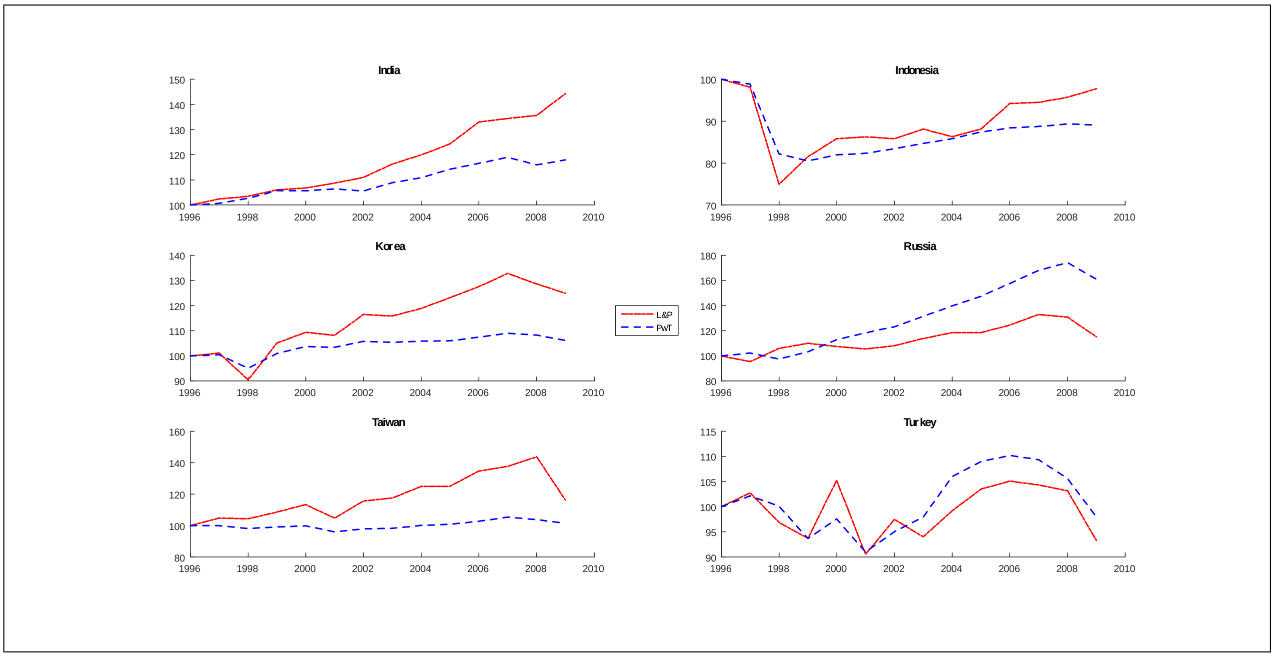


Figure 1.18: Country-level Aggregate TFP Index - Other Selected Countries

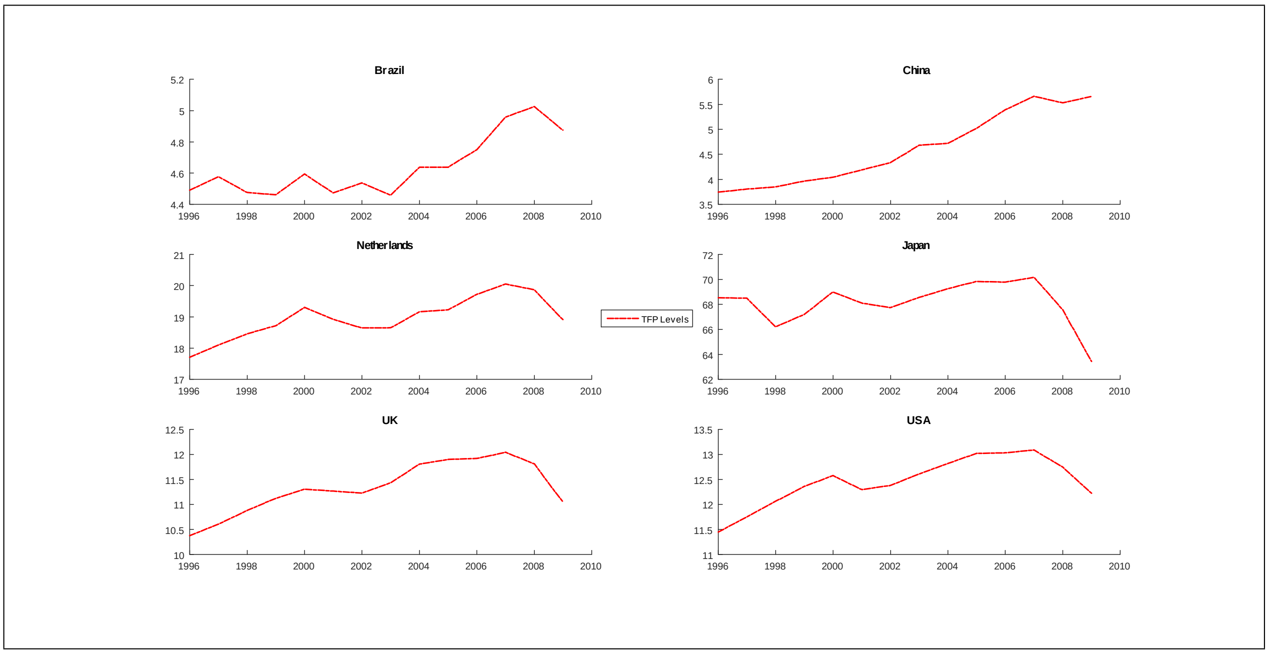


Figure 1.19: Country-level Aggregate TFP Levels - Selected Countries

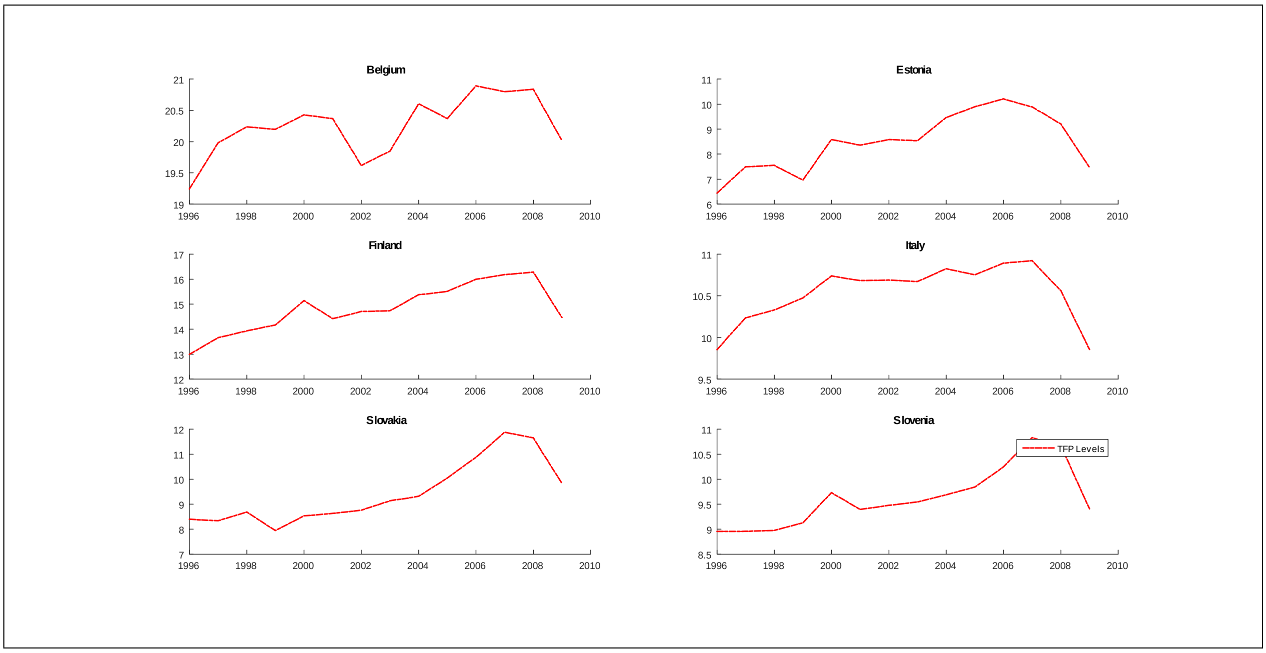


Figure 1.20: Country-level Aggregate TFP Levels - Euro-Zone Selected Countries

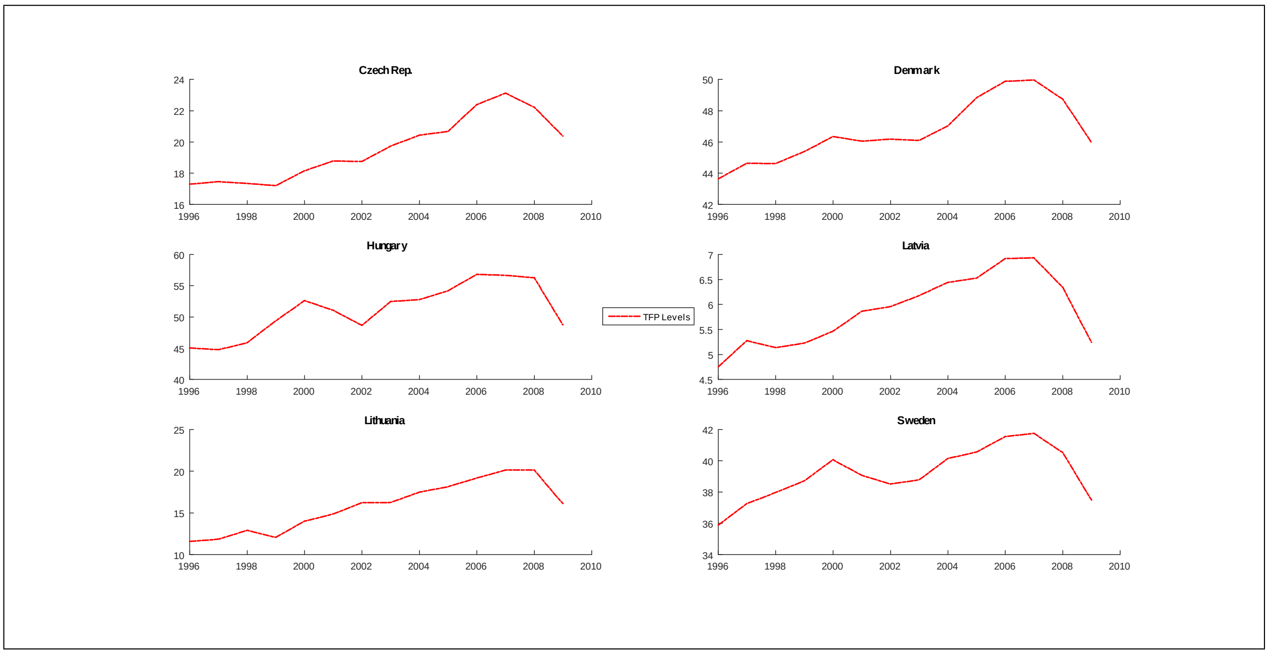


Figure 1.21: Country-level Aggregate TFP Levels - Non-Euro EU Selected Countries

Figure 1.22: Country-level Aggregate TFP Levels - Other Selected Countries

Appendix 3

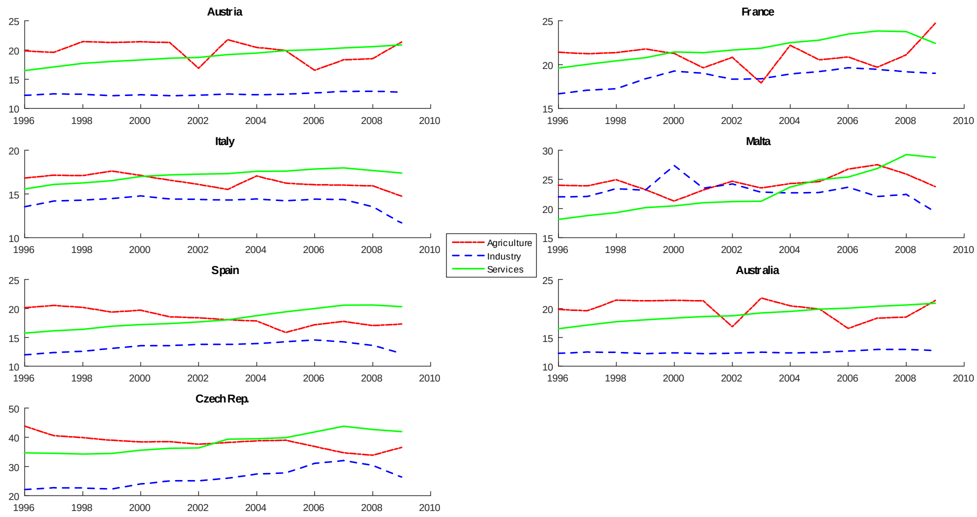


Figure 1.23: 3-Sector TFP Levels - Industry displaying low relative TFP

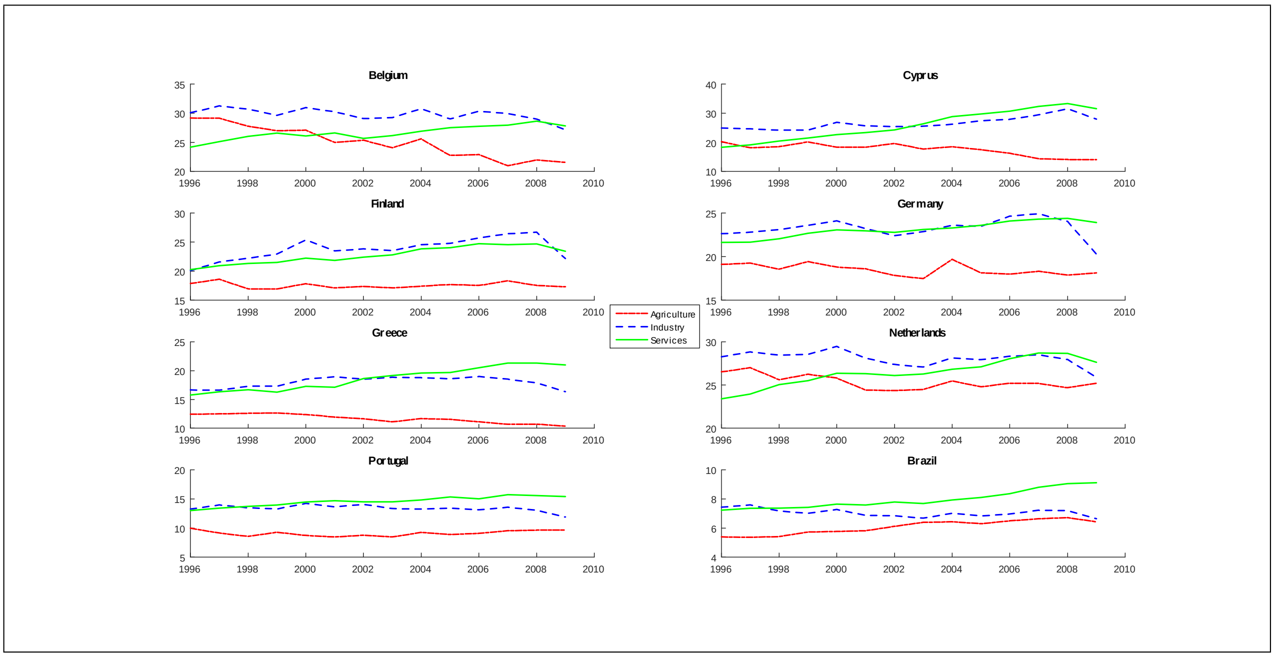


Figure 1.24: 3-Sector TFP Levels - Agriculture displaying low relative TFP

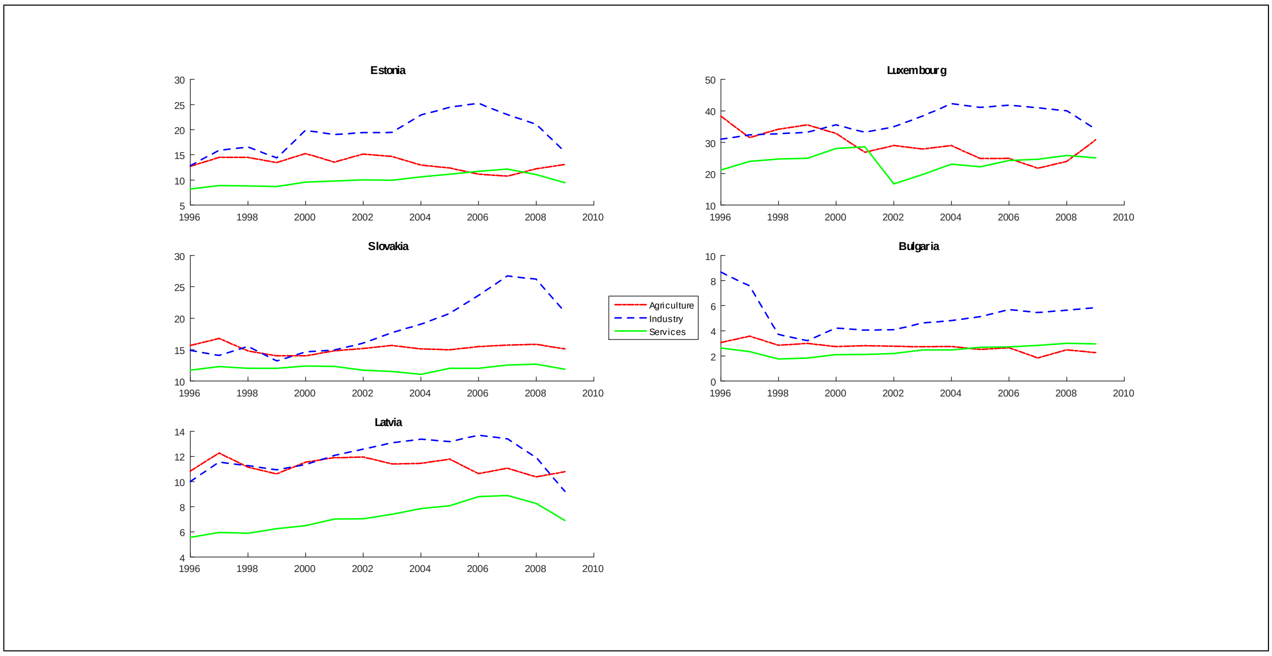


Figure 1.25: 3-Sector TFP Levels - Services displaying low relative TFP

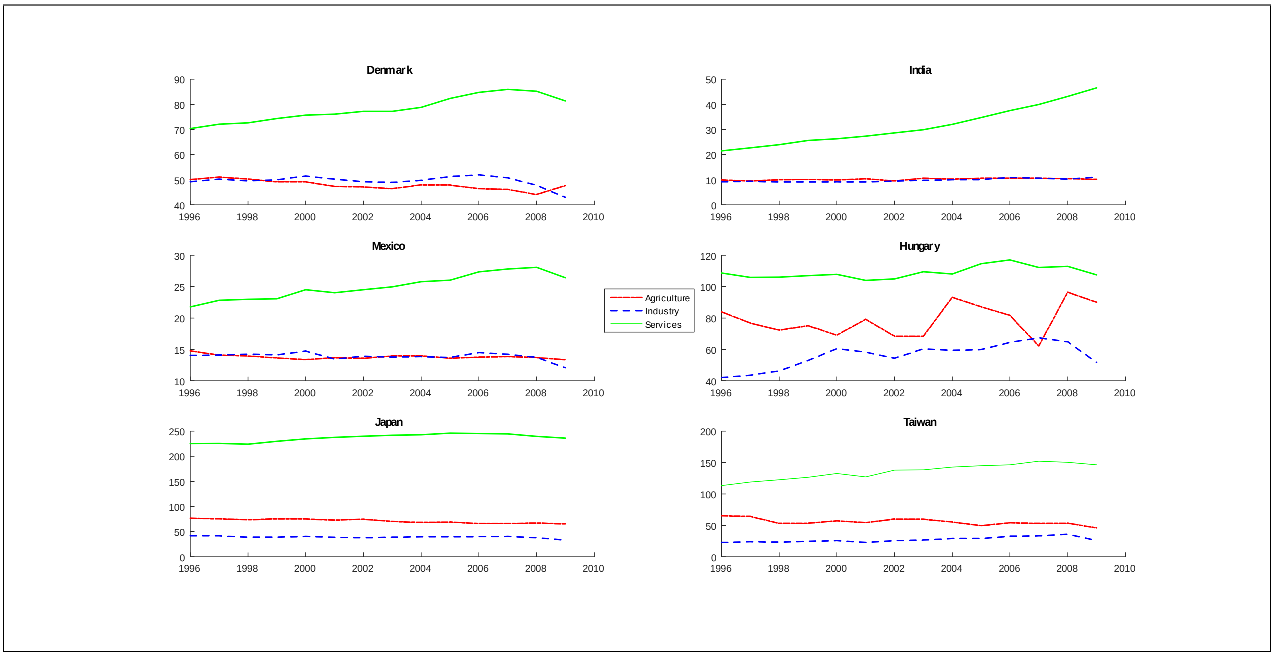


Figure 1.26: 3-Sector TFP Levels - Services displaying high relative TFP - Group 1

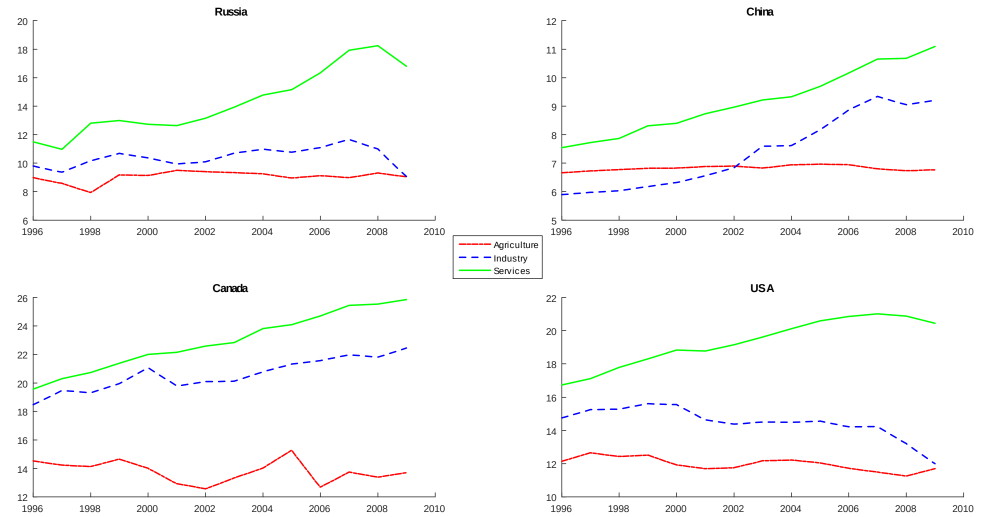


Figure 1.27: 3-Sector TFP Levels - Services displaying high relative TFP - Group 2

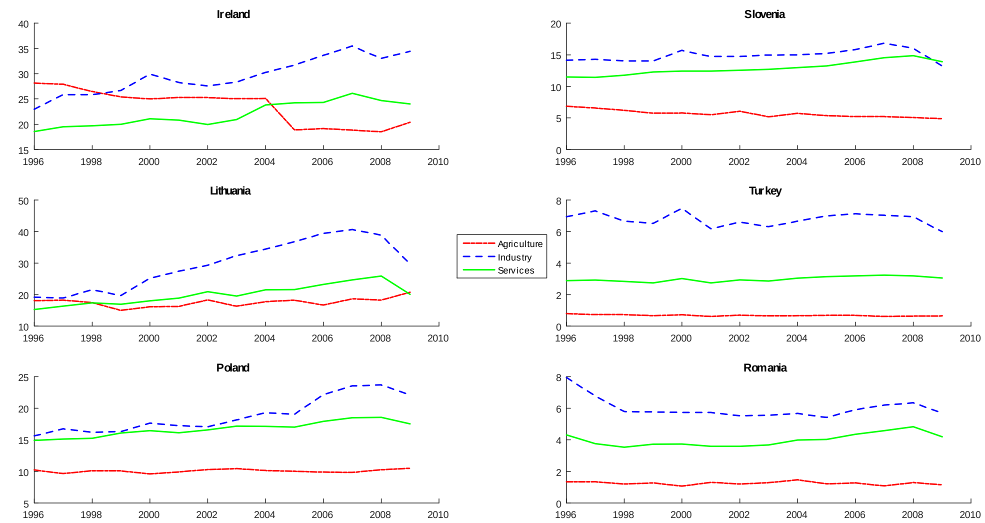


Figure 1.28: 3-Sector TFP Levels - Industry displaying high relative TFP

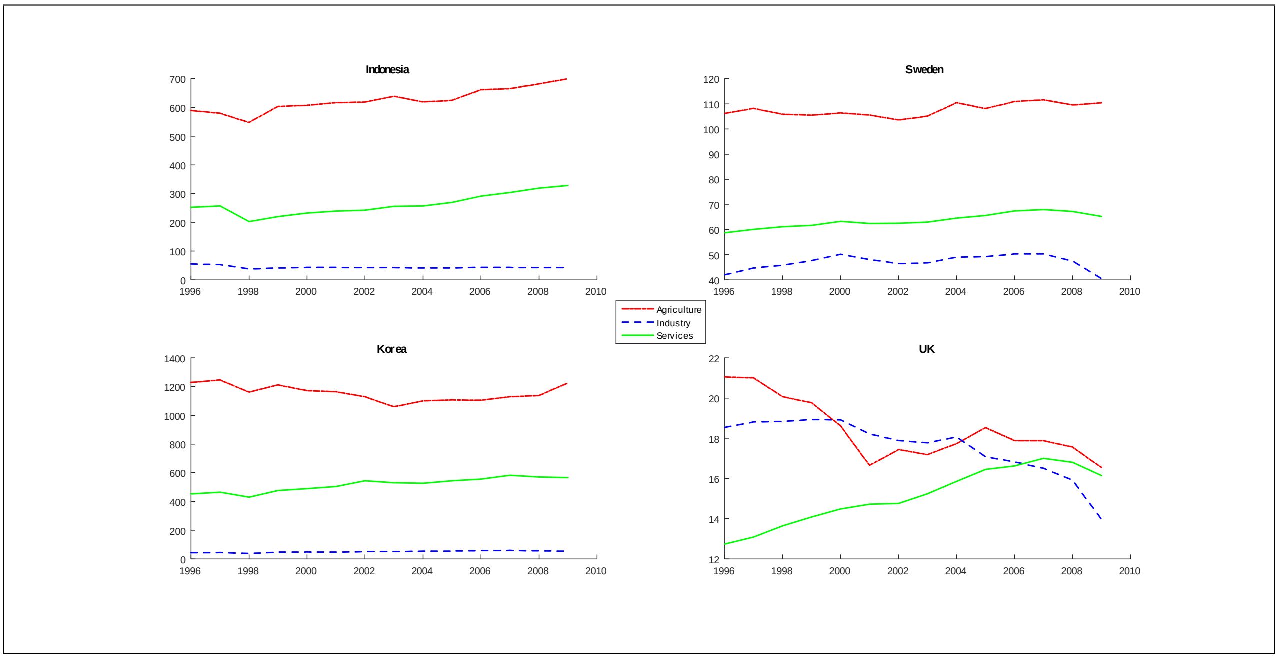


Figure 1.29: 3-Sector TFP Levels - Agriculture displaying high relative TFP

Table 1.1: ISIC 3.0 vs. 3-Sector Correspondence

	WIOD - ISIC 3.0		3-Sector
AtB	Agriculture, Hunting, Forestry and Fishing	1	Agriculture
C	Mining and Quarrying	2	Industry
15t16	Food, Beverages and Tobacco	2	Industry
17t18	Textiles and Textile Products	2	Industry
19	Leather, Leather and Footwear	2	Industry
20	Wood and Products of Wood and Cork	2	Industry
21t22	Pulp, Paper, Paper , Printing and Publishing	2	Industry
23	Coke, Refined Petroleum and Nuclear Fuel	2	Industry
24	Chemicals and Chemical Products	2	Industry
25	Rubber and Plastics	2	Industry
26	Other Non-Metallic Mineral	2	Industry
27t28	Basic Metals and Fabricated Metal	2	Industry
29	Machinery, Nec	2	Industry
30t33	Electrical and Optical Equipment	2	Industry
34t35	Transport Equipment	2	Industry
36t37	Manufacturing, Nec; Recycling	2	Industry
E	Electricity, Gas and Water Supply	2	Industry
F	Construction	2	Industry
50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	3	Services
51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	3	Services
52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	3	Services
H	Hotels and Restaurants	3	Services
60	Inland Transport	3	Services
61	Water Transport	3	Services
62	Air Transport	3	Services
63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	3	Services
64	Post and Telecommunications	3	Services
J	Financial Intermediation	3	Services
70	Real Estate Activities	3	Services
71t74	Renting of M Eq and Other Business Activities	3	Services
L	Public Admin and Defence; Compulsory Social Security	3	Services
M	Education	3	Services
N	Health and Social Work	3	Services
O	Other Community, Social and Personal Services	3	Services
P	Private Households with Employed Persons	3	Services

Capítulo 2

Assessing the Quantitative Importance of Sectoral Cost Shares for Total Factor Productivity Growth

2.1 Introduction

The input-output structure has been embodied in a large number of general equilibrium models, such as the seminal work of Long and Plosser (1983) and the most recent contributions of Acemoglu et al. (2015) and Duarte and Restuccia (2016). Such network systems are suitable for a wide range of cross-country exercises, and its rising importance encouraged the recent construction and dissemination of new comprehensive sectoral multi-country databases.

On the other hand, it has been well established by the long-run growth literature the utmost importance of cross-country differences on labor productivity and total factor productivity (TFP)[1] in explaining large shares of differences in income throughout the world. Also, new branches of this literature have dedicated great efforts to show how sectoral differences in productivity drive the process of reallocation of productive inputs across the many activities of an economy and, ultimately, can account for the aggregate productivity outcomes.

In this paper, we aim to evaluate the quantitative importance of sectoral cost shares in explaining sectoral and aggregate productivity growth. Starting from the model proposed by Long and Plosser (1983) to the real business cycle literature, Ferreira et al. (2016) provided an alternative analytical setup for estimating sectoral TFP and constructed multi-country sectoral productivity series for 40 countries and 35 activities, from 1996 to 2009, which are, up to the present date, the only sector-level total factor productivity series available.

Even though some estimates of labor productivity for a large set of countries and disaggregated activities have already been made[2], actual data on total factor productivity is still scarce, despite the well-known fact that total factor productivity is one of the main drivers of output growth. Due to this lack of a proper sectoral database on TFP, until the work of Ferreira et al. (2016), previous literature has used only labor productivity measures to discuss long-run growth.[3]

As a result from the hypothesis concerning the input-output structure of the model, the elasticities of commodity outputs with respect to commodity inputs are equal to the equilibrium cost shares. Therefore, the matrix of cost shares is at the core of the mechanism that drives

[1] In this paper, we use the expressions "total factor productivity", "TFP"and "productivity"interchangeably.

[2] See Duarte and Restuccia (2010), Duarte and Restuccia (2015) and Inklaar and Timmer (2014)

[3] For instance, see Baumol (1967), Baumol et al. (1985), Baumol (1986), McMillan and Rodrik (2011), Rodrik (2013), Herrendorf et al. (2014), and Ferreira and Silva (2015).

the propagation of productivity shocks through time and across sectors. Closely following this framework, we perform a comparative analysis concerning sectoral and country-level TFP growth rates in the USA and in Brazil and conduct two sets of counterfactual exercises. The primary purpose of these exercises is to assess to what extent changes on the cost shares associated with intermediate uses of outputs affect sectoral and aggregate total factor productivity growth.

More specifically, the question that guides our first and main set of counterfactual exercises is: What happens to Brazil's (sectoral and aggregate) total factor productivity growth if we replace the shares of its intermediate uses of **domestic** outputs in the total cost of its **industry** by the corresponding cost shares of the US economy? We then narrow this investigation through different directions. First, we restrict the change of the intermediate uses of domestic outputs to affect only a specific sector at a time. Second, we redo the exercises considering only the cost shares in activities assigned to manufacturing, following the classification of the GGDC 10-Sector Database.

The second set of counterfactuals emphasize the relevance of a country's specific choice of international trade partners - reflected on its preferred allocation of imported inputs - for its sectoral and total economy's productivities. For these alternative exercises, we also ask the previous questions, but we do not impose any restrictions: all cost shares of interest are replaced by the US economy's cost shares, including the ones reflecting intermediate uses of **imported** outputs.

We use data from the World Input-Output Database (WIOD) - which includes the World Input-Output Tables (WIOTs) and the Socio Economic Accounts (SEA) - for assessing patterns of TFP growth rates and performing the counterfactual exercises. This is is the same database that Ferreira et al (2016) adopted for constructing their sectoral total factor productivity series. The WIOD is the most up-to-date and comprehensive sectoral cross-country database, which enables a wide range of sectoral studies, as it provides data for 35 economic activities and 40 countries, from 1995 to 2009.[4]

As a result of the first set of exercises, we find that, depending on which cost shares we choose to replace, the impacts on sectoral and aggregate productivity are several and do not only take place in industry itself, but throughout the economy. In this sense, the best results - in terms of enhancing TFP growth - seem to be achieved when we replace Brazil's shares of its **domestic industry** in the total cost of its **industry** by the corresponding cost shares of the US economy, in that they are able to improve TFP in a higher number of activities and, as a result, to boost TFP growth rates in all three sectors and in total economy.

From the second set of counterfactuals, we conclude that the optimum choice of international suppliers, as well as the trade-off between domestic and imported inputs, as prescript by the model, are consistent with a more flourishing productivity scenario. In other words, the changes in the parameters of the productivity function, as prescripted by these counterfactuals, are followed by a equilibrium such that optimum allocation choices reveal scenarios of lower productivity growth.

This paper is organized as follows. In the next section, we present the model that theoretically supports our counterfactual exercises. In Section 3, we describe the main features of the database that supports our quantitative analysis, outline the identification strategy applied and present some stylized facts concerning total factor productivity. In Section 4 we present an in-depth comparative analysis related to patterns of sectoral and aggregate TFP's growth rates, as we assess which sector - or sectors - contributed for the observed growth in aggregate productivity in Brazil and in the USA and perform two sets of counterfactual exercises aiming to evaluate the quantitative importance of cost shares in explaining sectoral and aggregate productivity growth.provides the main results. Section 5 concludes.

[4] Although there are annual WIOTs until 2011, labor data obtainable from SEA is only available for the full set of 40 countries until 2009.

2.2 The Model

2.2.1 Dynamic General Equilibrium: Open Economy Setup

In this section, we present the model proposed by Ferreira et al. (2016). This setup closely follow the real business cycle model first proposed by Long and Plosser (1983), but it modifies the model's environment in order to account for the existence of international trade across many open economies, as the original model is suitable only for the analysis of a single closed economy.

The economy has a single infinite-lived individual (or a constant number of identical individuals), endowed with initial resources, production possibilities and preferences. The individual then has to choose, based on his marginal rate of substitution, a preferred consumption-production plan.[5]

To assess the impacts of international trade over each sector, suppose there are C countries engaged in international exchanges of goods and services. Therefore, the individual who solves the maximization problem have to consider the allocation of up to $N = I \times C$ commodities. In other words, an activity i, $i \in \{1, 2, ..., I\}$, whose production is specialized in one single sort of commodity, may have up to C different "plants"producing it, each of them based in one of the C countries.

The produced commodities thus differ in their own "nature", i.e., there are heterogeneous goods and services that can be assigned to different economic activities such as a "food, beverages and tobacco"or "wood and products of wood and cork", both within "industry", or to "hotels and restaurants", belonging to the service sector. But the commodities also differ according to their origin: they can be domestically produced or imported from other countries. It means that the representative agent need to decide the optimal allocation of the domestically produced commodities and of the ones produced abroad.

The economic activities in this environment may be summarized as repetitions of one-period cycle, each of them beginning with this individual's choice problem.

At the beginning of the period the individual chooses a consumption-production plan that maximizes the value of his expected discounted utility, constrained by the availability of resources and the production possibilities. At $t = 0$, the individual's utility U is given by:

$$U = \sum_{t=0}^{\infty} \beta^t u(C_t, Z_t), \qquad 0 < \beta < 1 \tag{2.1}$$

where β is a discount factor, C_t is a N-vector of commodity consumption at time t, and Z_t is the total amount of leisure (measured in time units) consumed in period t. As we can clearly notice from equation (2.1), preferences are assumed to be constant over time, i.e., there are no exogenous random shocks influencing the individual's tastes.

The one-period utility, $u(C_t, Z_t)$ is of the form:

$$u(C_t, Z_t) = \theta_0 \ln Z_t + \sum_{i-1}^{N} \theta_i \ln C_{i,t} \tag{2.2}$$

where $\theta_i \geq 0, i = 0, 1, \ldots, N$, and, in general, $\theta_0 > 0$. In this case, even if some commodity k has no direct consumption value, i.e., $\theta_k = 0$, it does not mean it is completely useless for the individual. It is important to have in mind that it may also serve as a input in the production of commodities.

In this economy, all commodities are produced. A given commodity may serve as an input in the production of others (and possibly in its own), and its production depends on positive

[5] It is interesting to observe that the optimal plan and the individual's marginal rate of substitution can be interpreted as, respectively, the quantities and relative prices at a competitive market economy, therefore being capable of generating multi sector rational expectations equilibria.

quantities of other commodities. It is also assumed that every commodity in this economy is "perishable", which means that the available commodity stocks at the beginning of each period are composed entirely by units produced during the previous period. In other words, it is assumed a depreciation rate of 100% per period.[6]

During every period, various random shocks modify the productive transformations, although they cannot influence the individual's tastes. Thus, the total commodity stocks that will be available at the beginning of the subsequent period are derived from the combined result of the input choices made at the beginning of the current period and the random shocks to the production activities that occur along the period.

The production possibilities exhibit constant returns of scale and take the form:

$$Y_{t+1} = F(L_t, X_t; \lambda_{t+1}) \tag{2.3}$$

where Y_{t+1} is a N-vector, and its ith element, $Y_{i,t+1}$, is given by the total stock of commodity i available at time $t+1$, $F(\cdot,\cdot;\cdot)$ is a N-vector-valued function, assumed to be concave and linearly homogeneous with respect to L_t and X_t, L_t is a N-vector whose ith element, $L_{i,t}$, is given by the number of hours allocated at time t to the production of commodity i, X_t is a matrix of order $N \times N$ and its i,j element, $X_{ij,t}$, is given by the amount of commodity j allocated to the production of commodity i at time t, and λ_{t+1} is a random vector whose value is realized at time $t+1$. It is also assumed that the vector-valued stochastic process $\{\lambda_t\}$ is an observable, time-homogeneous Markov process.

The production functions are assumed to be of the following form:

$$Y_{i,t+1} = \lambda_{i,t+1} L_{i,t}^{b_i} \prod_{j=1}^{N} X_{ij,t}^{aij} \tag{2.4}$$

where $b_i \geq 0, i = 1, \ldots, N$, $a_{ij} \geq 0, i,j = 1, \ldots, N$ and $\sum_{j=1}^{N} a_{ij} + b_i = 1, i = 1, \ldots, N$.

Note that, except from the stochastic technological parameters $\{\lambda_t\}$ - which are, precisely, the total factor productivity vectors we are interested on - this is a standard Cobb-Douglas technology.

Some considerations regarding $\{\lambda_t\}$ - which denotes the infinite stochastic sequence $\lambda_0, \lambda_1, ..., \lambda_t$ - are worth to be made. As it was assumed that this sequence follows a time-homogeneous Markov process, it has the property that the conditional distribution of $\lambda_{t+\tau}$, $\tau > 0$, given $\lambda_t, \lambda_{t-1}, \lambda_{t-2}, ...$depends only on τ and on the value of λ_t. This is equivalent to saying that these processes are uniquely defined by a "one-step-ahead"conditional distribution function, $G\left(\lambda_{t+1}|\lambda_t\right)$. But this assumption does not constrain the process to be stationary or to have no drift. It also does not constrain individual elements or scalar-valued functions of λ to be Markov processes.

Therefore, since the production function F does not depend on the value of t per se, technological change can be represented by drift and/or time-series dependence on the process $\{\lambda_t\}$.On the other hand, if the vectors in $\{\lambda_t\}$ are independent and identically distributed (i.i.d.), there is no technological change. As there is a wide range of both theoretic and empirical studies documenting the primary impacts of technological change on economic growth, we can expect our series to follow a process with a drift and/or time-series dependence; i.e., the observable shocks will not be i.i.d..

The individual's choices are constrained by the amount of time (fixed, that must be allocated between leisure and work) and by the total commodity stocks that are available at the beginning of each period. These two resource constraints should be satisfied at each period.

The first one concerns the labor/leisure choices. If H denotes the total fixed stock of time available per period, then:

[6] This assuption, although not being essencial the model, simplifies the solution to the recursive problem.

$$Z_t + \sum_{i=1}^{N} L_{i,t} = H, \qquad t = 0, 1, 2, \ldots \tag{2.5}$$

The commodity allocation constraint is given by:

$$C_{j,t} + \sum_{i=1}^{N} X_{ij,t} = Y_{j,t}, \qquad j = 1, 2, \ldots, N; \qquad t = 0, 1, 2, \ldots \tag{2.6}$$

Lastly, the decision variables - the allocations (C_t, Z_t, L_t, X_t) - chosen by the individual at time t, are assumed to depend only on observable information at time t. Hence, with $S_t \equiv (Y_t, \lambda_t)$ denoting the state vector at time t, the allocations at time t are functions of S_t.

2.2.2 Expected Utility Maximization

The individual then must choose a consumption-production plan at time t to maximize his expected utility, given by

$$E\left(U|S_t\right) = \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s, Z_s)|S_t\right] \tag{2.7}$$

subject to the production possibilities constraint (2.4) and to the two resource constraints (2.5) and (2.6).

Furthermore, the individual's preferences are such that if the welfare function, $V(S_t)$, is defined as the maximum value of $E\left(U|S_t\right)$,

$$V(S_t) \equiv \max \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C_s, Z_s)|S_t\right]$$

s.t. (2.3), (2.5) and (2.6)

$$= \boldsymbol{E}\left[\sum_{s=t}^{\infty} \beta^{s-t} u(C(S_t), Z(S_t))|S_t\right] \tag{2.8}$$

then V and the optimal allocation plan are jointly the solution to:

$$V(S_t) = \max_{d_t} \left\{u(C_t, Z_t) + \beta E\left[V\left(S_{t+1}\right)|S_t\right]\right\} \tag{2.9}$$

where d_t stands for all current decision variables at time t, which are: $L_{i,t}$, $C_{i,t}$, $X_{ij,t}$, $i, j = 1, \ldots, N$.

In general, this functional equation does not admit a closed form solution. However, besides restricting the utility function to be logarithmic, the additional assumption of a Cobb-Douglas technology fulfill the set of sufficient conditions that guarantee a analytic (closed form) solution to this problem.[7]

[7] See Christiano (1990) and Mehra (2005).

Moreover, functional equations like the Bellman equation (2.9) are solved by iterative procedures or by guess and verify. Long and Plosser (1983) provided the following value function, i.e., the solution to the individual's intertemporal maximization problem:[8]

$$V(S_t) = \sum_{i=1}^{N} \gamma_i \ln Y_{i,t} + J(\lambda_t) + K \tag{2.10}$$

where $\gamma_j = \theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij},\ j = 1, 2, \ldots, N,\ J(\lambda_t) = \beta E \left[\sum_{i=1}^{N} \gamma_i \ln \lambda_{i,t+1} + J(\lambda_{t+1}) | \lambda_t \right]$ and K is a constant that only relies upon on preference and production parameters, but not on state variables, Y_t or λ_t.

2.2.3 Optimal Quantities

Solving (2.9), one can show that, at time t, optimal consumption, leisure, commodities and labor inputs are, respectively, given by:

$$C^*_{i,t} = \left(\frac{\theta_i}{\gamma_i} \right) Y_{i,t}, \qquad i = 1, 2, \ldots, N \tag{2.11}$$

$$Z^*_t = \theta_0 \left(\theta_0 + \beta \sum_{i=1}^{N} \gamma_i b_i \right)^{-1} H, \tag{2.12}$$

$$X^*_{ij,t} = \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right) Y_{j,t}, \qquad i, j = 1, 2, \ldots, N \tag{2.13}$$

$$L^*_{i,t} = \beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H, \qquad i = 1, 2, \ldots, N \tag{2.14}$$

where $\{\gamma_j\}$ is given by $\gamma_j = \theta_j + \beta \sum_{i=1}^{N} \gamma_i a_{ij},\ j = 1, 2, \ldots, N$.

Note that, in equation (2.11) the portion of the total available stock of a given commodity allocated to final consumption is directly proportional to its consumption value. Similarly, as one can see in equation (2.13), the amounts of a commodity allocated as an input in the production of a given commodity (and possibly in its own) is an increasing function of its productivity in that employment. Also, from equations (2.12) and (2.14), note that the same principle applies to the allocation of the total fixed stock of time available per period.

On the other hand, these equations show that the bigger the total available stock of a given commodity (or time), the more intensive will be its allocation as a productive input and to positively valued consumption (or leisure). Long and Plosser (1983) highlighted this principle as being the most important feature of the optimal decision rules, specially (2.13), in that it is the primary source of persistence and comovement in the consumption, input and output series.

To understand how these propagation mechanisms work, suppose that, at time t, an output shock - e.g. a TFP shock to the output - makes the total available stock of a given commodity unexpectedly high. Then, at time t, the inputs of this commodity in all of its alternative

[8] Following Long and Plosser (1983), this solution can be obtained by "dumb luck", due to the particular preferences and production possibilities assumed. However, the validity of this solution for V can be verified by the following steps. First, assume V is given by (2.10). Then, do the maximization with respect to time t consumption and input decisions on the right-hand side of (2.9). Finally, note that the maximum on the right-hand side of (2.9), as a function of S_t, is given by $V(S_t)$ as defined by (2.10). Ferreira et al. (2016) show all the steps for this verification and for solving the model, in Appendix 1.

employments will also be unexpectedly high. It is equivalent to saying that, in this model, output shocks not only propagate forward in time, but also its future effects spread across the sectors of the economy.

Other three aspects of the decision rules are worth noting. First, at time t, the allocation of a given commodity (or time) does not depend on the available amounts of other commodities. Second, given the total available stock of output at time t, none of the allocations depends on λ_t.Finally, as the labor/leisure allocations are also independent of Y_t and, by assumption, the total stock of time remains constant, these allocations do not change over time.[9]

2.2.4 Dynamics

Note that, by substituting the optimal values of the production inputs, given by (2.13) and (2.14), into the production function (2.4) and taking logs, we can derive an extremely simple and intuitive equation for the dynamics of output. Letting $y_t \equiv \{\ln Y_{i,t}\}$ denote a $N \times 1$ vector of outputs, we obtain:

$$y_{t+1} = Ay_t + k + \eta_{t+1} \tag{2.15}$$

where A is the $N \times N$ matrix of parameters $\{a_{ij}\}$, k is a $N \times 1$ vector of constants and η_{t+1} is the $N \times 1$ stochastic vector $\{\ln \lambda_{i,t+1}\}$.

Recall that the elements of the A matrix are, by construction, the elasticities of commodity outputs with respect to commodity inputs. These parameters have been already defined together with other elements of the production function (2.4). As it will become clear on section 3.2, some of the model's assumptions facilitate the identification of the parameters' values from available information in our database.

The hypothesis that many commodities are used as inputs in the production of many (commodity) outputs directly implies that many columns of the A matrix are full of positive elements. The relevance of this assumption can be observed from the dynamic behavior of the output, given by (2.15).

Suppose that, at time t, the output of a given commodity i, $y_{i,t}$, corresponding to one of these columns is unexpectedly high. For instance, this may occurr due to an unexpected technological shock that shifted up the value of the total factor productivity parameter $\lambda_{i,t}$ of this specific sector (which obviously made $\eta_{i,t}$ also higher and, consequently, increased the value of $y_{i,t}$). Then, in $t+1$, the outputs of all of the commodities that employed commodity i as productive input will also be higher. This is, precisely, the mechanism that drives the propagation of exogenous shocks both through time and across sectors that we have explained in the previous section.

It is straightforward to show that the ith element of vector y_t is given by:

$$y_{i,t+1} = \sum_{j=1}^{N} a_{ij} y_{j.t} + k_i + \eta_{i,t+1} \tag{2.16}$$

where

$$k_i = b_i \ln \left[\beta\gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H \right] + \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta\gamma_i a_{ij}}{\gamma_j} \right) \tag{2.17}$$

Note that if we consider the admissible - yet unrealistic - scenario in which the vectors in the sequence $\{\lambda_t\}$ are iid, then the A matrix is the only responsible for the intertemporal links between deviations of outputs from their expected values. Moreover, the preference parameters

[9] In other words, the model do not reproduce the procyclical behavior of labor employment. There is an extensive related discussion in Long and Plosser (1983).

(β and θ_i, $i = 0, 1, .., N$) influence the dynamics of outputs, as the vector of constants k is a function of them.[10]

2.3 Stylized Facts

2.3.1 Data

In this paper, we use data from the World Input-Output Database (WIOD) for assessing patterns of TFP growth rates and performing counterfactual exercises. This is is the same database that Ferreira et al (2016) adopted for constructing their sectoral total factor productivity series.

The WIOD - which includes the World Input-Output Tables (WIOTs) and the Socio Economic Accounts (SEA) - is the most up-to-date and comprehensive sectoral cross-country database. This new database enables a wide range of sectoral studies, as it provides data for 35 economic activities and 40 countries, from 1995 to 2009. The countries covered by the WIOD respond to more than 85% of world GDP.[11]

For our purposes, the most interesting feature of the WIOTs is that they are valuated at basic prices, i.e., all values in their intermediate and final use blocks represent the amount receivable by the producer from the purchaser. The construction methodology of these tables guarantees that the trade and transport margins cannot interfere in their valuation, as they are recorded in separate rows. In other words, the valuation method adopted ensures that our results are not going to be dictated by expenditure prices, and thus it secures our conclusions against producing misleading inferences.

The basic price valuation best reflects the underlying cost structures of economic activities, by separating the use of goods from the use of trade and transport services. As argued by Timmer et al. (2012b), this valuation strategy suits well input-output analysis in which production technology plays a central role.[12]

Sectoral productivity analyses have been constrained by the lack of an appropriate sectoral database. The WIOD has helped filling this gap, since it encompasses a large amount of multilateral sectoral data in a coherent framework.[13] Moreover, Ferreira et al. (2016) showed that it is possible to construct multi-country sectoral time series for total factor productivity by combining data provided by the WIOTs and the SEA. Recall that, as both are included on the WIOD, these datasets cover the same sets of countries and activities, and present data for the period from 1995 to 2009.

From the Socio-Economic Accounts (SEA), the authors obtained the variable "labor compensation"for each of the 35 activities in the 40 countries. This variable was crucial to the computation of the sectoral total factor productivity series, as it influences each economic activity's cost shares magnitudes.[14]

[10] Due to the format of the other variables' allocation rules, e.g. consumption and production inputs, the dynamic behavior of these varibles can be directly obtained from the dynamics of outputs.

[11] The countries covered are: Australia, Austria, Belgium, Bulgaria, Brazil, Canada, China, Cyprus, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Indonesia, India, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Latvia, Mexico, Malta, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Sweden, Turkey, Taiwan and United States. Hence, the WIOD covers 27 EU countries and 13 other major countries. All remaining countries are proxied by a region called "Rest of the World (RoW)", which had to be modelled due to the lack of sufficient data.

[12] For further information concerning the importance of the WIOD for sectoral studies and its construction methodology, refer to Ferreira et al. (2016) and Timmer, M. et al.. (2012b).

[13] Dietzenbacher, E. et al. (2013) provide an extensive explanation about the underlying principles and choices for the construction of the WIOD.

[14] Although there are annual WIOTs until 2011, labor data obtainable from SEA is only available for the full set of 40 countries until 2009.

From the SEA they also obtained the "price levels of gross output". Since the WIOTs are available in current prices (dollars), these indices were used to compute gross output series in constant prices (the base year chosen whas the first one available, 1995). Also, while the SEA are denominated in national currencies, the WIOTs are denominated in US dollars. Fortunately, the exchange rates that were adopted to convert national values into US dollars are available.

For every year in the sample period (1995-2009) and for each of the 35 economic activities and 40 countries, the World Input-Output Tables (WIOTs) provide values of intermediate inputs (alternatively labeled "intermediate consumption"), disaggregated by country and by activity of origin. Each of these series' values represents how much a given intermediate input costs to a certain producer, i.e., the net value (excluding transport margins and net taxes) paid from a producer to a specific supplier. Alternatively, it gives the exactly amount received by a given producer from a specific purchaser of his products.

Note that, as there are 1400 "type-and-country-denominated" economic activities (related to 35 activities and 40 countries), each of these bilateral trades involve producers that may operate in the same economic activity or in different ones, and that can be based at the same country or even at different continents.

2.3.2 Identifying the series' components

In this section, we closely follow Ferreira et al. (2016) and reproduce their identification strategy of the parameters for the construction of the total factor productivity sectoral series.

Rearranging the equation for the dynamics of output, given by equation (2.15), we obtain an equation for the log of the sectoral total factor productivities:

$$\eta_{t+1} = y_{t+1} - Ay_t - k \tag{2.18}$$

As annual sectoral output data is readily available at the WIOTs, to derive the values of the TFP shocks it is only necessary to obtain the A matrix and the vector of constants, k. This vector is a function of the preferences and technology parameters of the model, i.e., it does not depend on the state variables $S_t = (Y_t, \lambda_t)$.

On the other hand, by construction, the elements of the A matrix are the elasticities of commodity outputs with respect to commodity inputs. However, due to the hypothesis of constant returns of scale, these elasticities are equal to the equilibrium cost shares, i.e., a_{ij} is the equilibrium share of input j in the cost of output i, and so it can be expressed by the ratio:

$$a_{ij} = \frac{P_{j,t}X^*_{ij,t}}{W_t L^*_{i,t} + \sum_{k=1}^{N} P_{k,t}X^*_{ik,t}} \tag{2.19}$$

Accordingly, the A matrix is an input-output matrix, in terms of cost shares. As every commodity may serve as an input in the production of a great number of different commodities, many columns of this matrix are often full of positive elements. Besides, the sum of all the elements that compound a given row of the A matrix must be equal to one minus labor's cost shares, and, for this reason, it is appropriate to say that it measures the capital intensity of the corresponding sector:

$$\sum_{j=1}^{J} a_{ij} = 1 - b_i$$

To construct the A matrices of cost shares, Ferreira et al. (2016) evaluated the cost shares of every given input in the production of all of the economic activity's output. These cost shares were obtained by combining some of the above-mentioned information provided by the WIOTs and the SEA.

More precisely, this exercise required the values on "labor compensation- provided by the SEA - and on the "value of intermediate inputs- provided by the WIOTs - for every possible economic activity, i.e, at the highest available degree of disaggregation of the ISIC 3.0 classification. The authors constructed fifteen A matrices, one for each period (1995 to 2009). As the WIOD covers 35 economic activities and 40 countries, each A matrix is a 1400×1400 square matrix. However, for protecting the results from a possible bias introduced by the variation of these matrices' entries over time, they end up working with an averaged matrix. Therefore, the elements of the A matrix are time-invariant, as assumed by the theory. [15]

To obtain sectoral TFP, it was also necessary to identify the vector k. Note from equation (2.17) that k is a vector of constants, whose ith element is given by:

$$k_i = b_i \ln \left[\beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H \right] + \sum_{j=1}^{N} a_{ij} \ln \left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right)$$

But recall that, rearranging the equations for the equilibrium quantities of commodities and labor inputs - equations (2.13) and (2.14), respectively - we have that:

$$\left(\frac{\beta \gamma_i a_{ij}}{\gamma_j} \right) = \frac{X^*_{ij,t}}{Y_{j,t}}, \qquad i,j = 1,2,\ldots,N$$

and

$$\beta \gamma_i b_i \left(\theta_0 + \beta \sum_{j=1}^{N} \gamma_j b_j \right)^{-1} H = L^*_{i,t}, \qquad i = 1,2,\ldots,N$$

Then, properly replacing these equivalences on the equation for each ith element of vector k gives us:

$$k_i = b_i \ln \left(L^*_{i,t} \right) + \sum_{j=1}^{N} a_{ij} \ln \left(\frac{X^*_{ij,t}}{Y_{j,t}} \right), \qquad t = 1,2,...$$

$$k_i = b_i l^*_{i,t} + \sum_{j=1}^{N} a_{ij} \left(x^*_{ij,t} - y_{j,t} \right), \qquad t = 1,2,... \tag{2.20}$$

where $l^*_{i,t} \equiv \ln L^*_{i,t}$, $x^*_{ij,t} \equiv \ln X^*_{ij,t}$ and $y_{j,t} \equiv \ln Y_{j,t}$.

Fortunately, all of the components of equation (2.20) are obtainable from the SEA and the WIOTs.[16] A particular feature of this equation, highlighted by Ferreira et al. (2016), is that although, by construction, vector k is a function of the preferences and technology parameters of the model (see equation (2.17)) and, given this, it does not depend on the state variables $S_t = (Y_t, \lambda_t)$ - its equation could be rewriten as a function of the optimal quantities of both commodities and labor inputs at each time period, t.

At first, these two statements may seem inconsistent. But, if on the one hand, we have already shown that the optimum allocation of labor hours does not change over time, on the other hand, for every sector i, the optimal shares of each input j allocated for the production of output i relative to the total available quantity of the same input does not change over time either. Therefore, each entry of vector k is a constant.

[15] A more detailed description of the construction of the A matrices will be presented in section 3.

[16] For further details, refer to Ferreira et al. (2016).

However, when one looks at the data on sectoral hours worked (provided by the SEA) - the *proxy* for labor input -, and on the shares of each input used at a given sector over its total existing amount (which can be calculated from WIOTs' data), in fact, these quantities are not time invariant. To circumvent these findings, which are at odds with the model's predictions, the authors first identify 15 vectors k, one for each year from 1995 to 2009, which are of order 1400×1, but end up working with an averaged (time-invariant) vector.

Solving for the sectoral TFP levels in (2.18), Ferreira et al. (2016) compute annual level series of TFP for the 35 activities, by country, at 14 years (from 1996 until 2009). These levels can also be translated into indices of sectoral TFP - reflecting sectoral TFP growth rates, by normalizing the initial levels of the series (1996=100).

The main products of the authors' first exercise are 1400 series (for 35 activities and 40 countries) of multi-country sectoral TFP levels and indices of multi-country sectoral TFP, both denominated in constant[17] national currencies. After obtaining these sectoral series, the 35 activities are aggregated into 3 - agriculture, industry and services - according to correspondence depicted on Table 1, presented in Appendix. All of the aggregation procedures are conducted at the levels of the intermediate consumption, gross output, labor compensation and hours worked, i.e., at the series directly obtained from the WIOD. Only after that, each of the calculations detailed on the last section are redone.

After aggregating the thirty-five activities into three major sectors, the A matrix become of order 120×120 and the vector k of order 120×1. This new exercise provides 120 series (related to 3 sectors and 40 countries) of multi-country sectoral TFP levels and indices of multi-country sectoral TFP, denominated in national currencies. Finally, to be able to compare the total factor productivities with the ones provided by the Pen World Table (PwT)[18], the series are once again aggregated to country-levels, resulting on 40 series of total economy's TFP.[19]

In the next sections, we assemble some stylized facts concerning total factor productivity. All of the series were calculated and provided by Ferreira et al. (2016).

2.3.3 Multi-Country3-Sector TFP Growth Rates

Next, the three following figures contrast each country's annualized growth rate of aggregate TFP with its annualized growth rate of sectoral TFP, respectively, on agriculture, industry and services (reflecting TFP growth observed for the period 1996-2009).

[17] Base year = 1995.

[18] Pen World Table provides country-level indices of TFP at constant national prices - variable "rtfpna". The version used was 8.1 (Feenstra, R.C., Inklaar, R. and Timmer, M.P. (2015)).

[19] Two observations must be made. First, as the series provided by Ferreira et al. (2016) resulted from an unprecedented effort to construct sectoral TFP series, it was not possible to compare the disaggregated measures with alternative indices. Second, the methodology the authors have chosen is completely different from PwT's, in that, *a priori*, they were unable to predict high positive correlations between the two alternative measures.

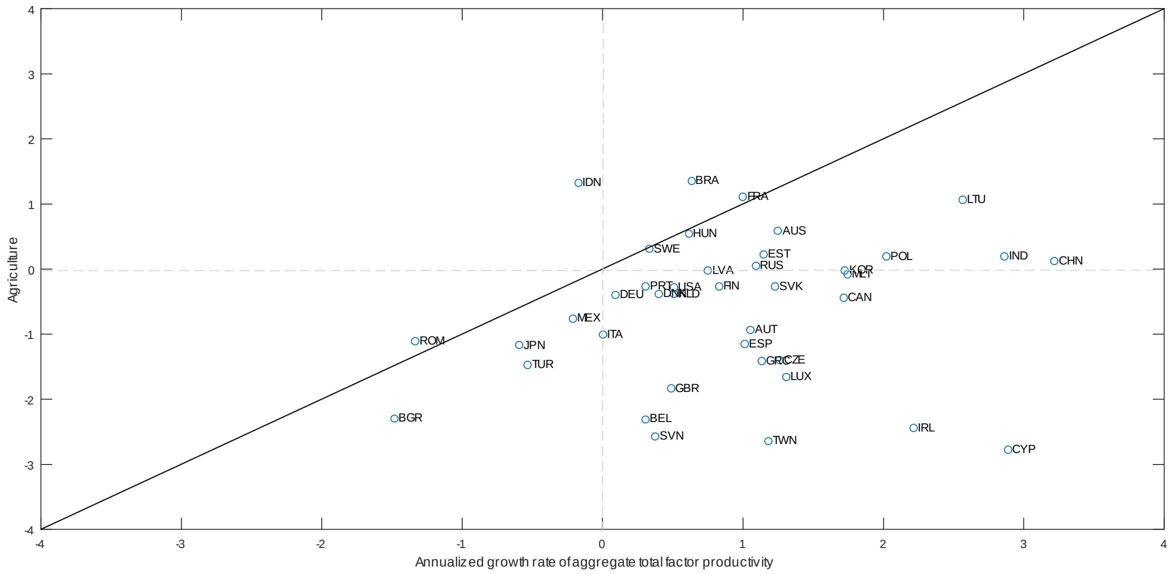


Figure 2.1: Annualized Growth Rates of TFP: Agriculture vs. Total Economy

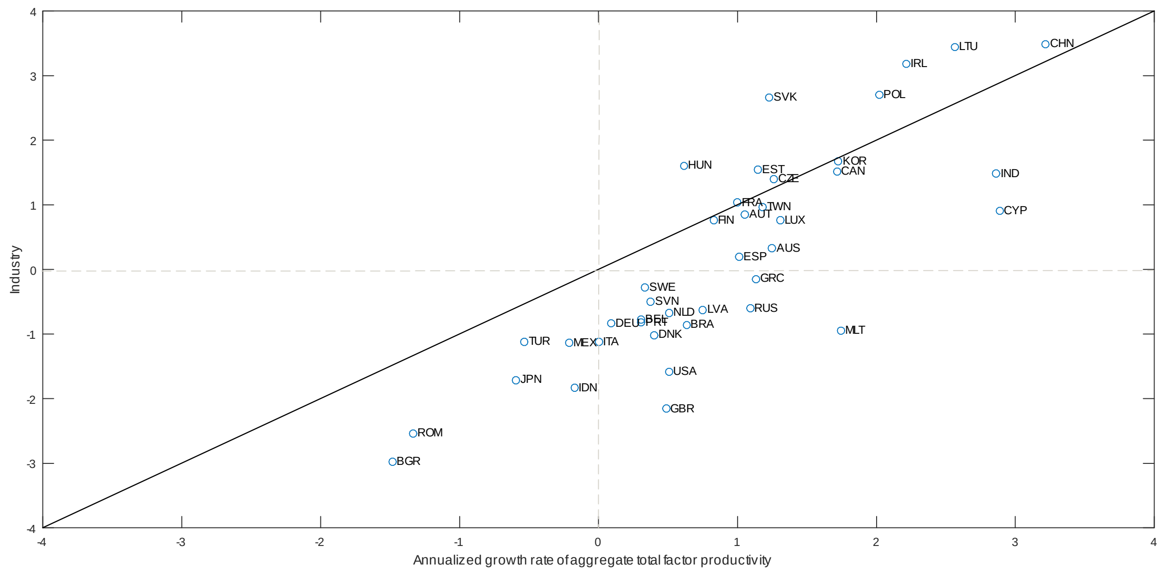


Figure 2.2: Annualized Growth Rates of TFP: Industry vs. Total Economy

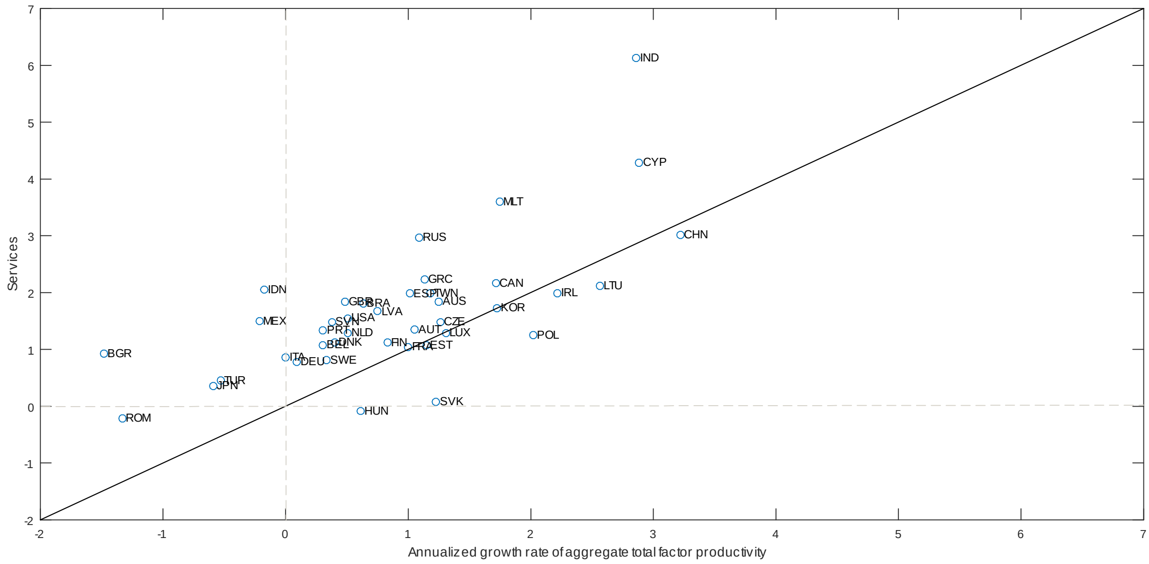


Figure 2.3: Annualized Growth Rates of TFP: Services vs. Total Economy

From Figure 1 note that, although there has been some considerable dispersion in relative growth rates, only four countries have experienced higher annualized growth rates of TFP in agriculture than in the respective economy aggregate: Brazil, France, Indonesia and Romania.

Figure 2 shows that industry's relative growth rates were far more concentrated than the agriculture ones but, once again, only a little number of countries had higher annualized growth rates of TFP in industry than in the respective economy aggregate: China, Czech Republic, Estonia, France, Hungary, Ireland, Lithuania, Poland and Slovakia.

Lastly, contrary to what is observed in the two other sectors, Figure 3 indicates that the growth rates of TFP in services were usually higher than the aggregate growth rates for most of the countries. Besides, note that all of the countries presenting annualized growth rates of TFP in industry higher than their aggregate growth rates, also presented low relative growth rates in services.

2.3.4 Multi-Country 3-Sector TFP Levels

In this section we outline some relevant sectoral stylized facts obtained from the multi-country 3-sector TFP level series.

Figures 4 and 5 show, for the years of 1996 and 2009 respectively and for every country on our sample, the ratio between their TFP levels in services and their TFP levels in industry in the corresponding year.

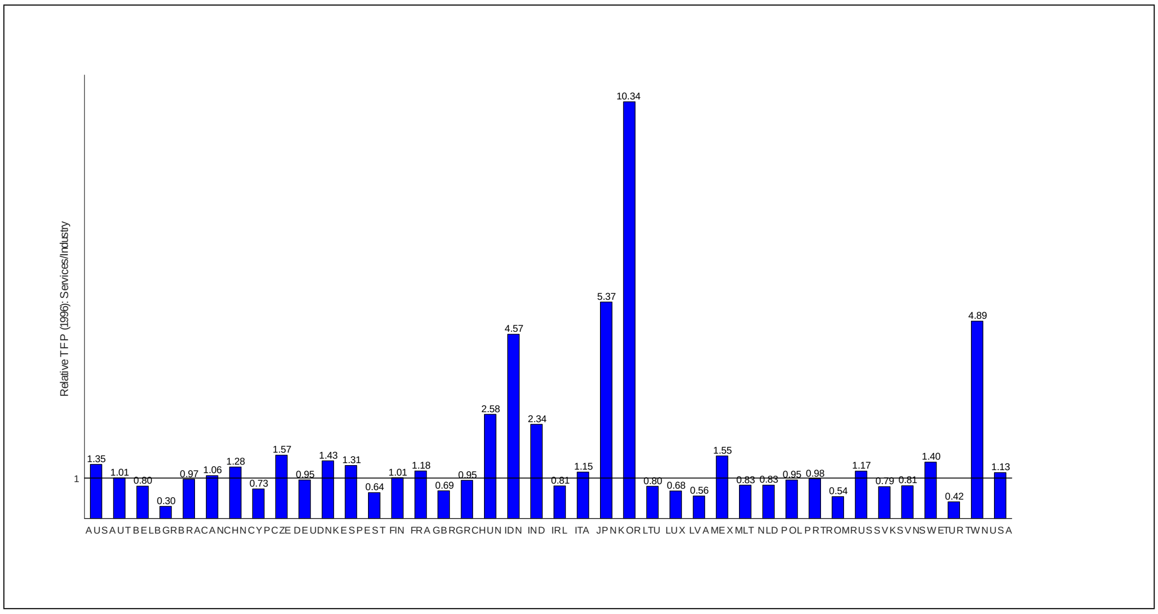


Figure 2.4: Relative Total Factor Productivity: Services-Industry Ratio for Forty Economies in 1996

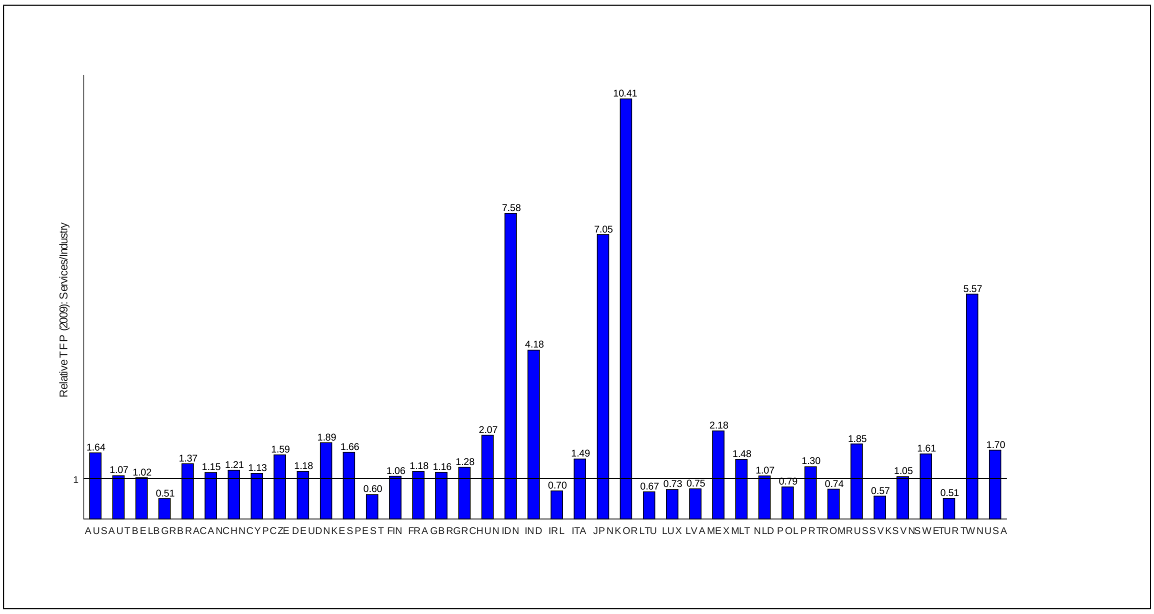


Figure 2.5: Relative Total Factor Productivity: Services-Industry Ratio for Forty Economies in 2009

In 1996, productivity in the services sector was higher than in industry for exactly half of the countries of our sample. For Asian countries such as Korea, Japan, Taiwan and Indonesia, TFP in services was already more than four times TFP in industry. On the other hand, for countries such as Brazil, Netherlands and the UK, this ratio was lower than one, indicating the opposite relation.In constrast, in 2009, three-fourths of the countries presented productivity in services higher than in industry. Therefore, over fourteen years, the productivity scenario has changed for ten countries whose industry was relatively more productive than services in 1996.[20]

Moreover, for thirty three of forty countries analyzed, the services-industry ratios in 2009 were higher than in 1996, indicating that productivity in services has grown more than in industry over the years. In fact, productivities in industry have actually dropped in twenty one countries of the sample, including Brazil, Germany, Denmark, Indonesia, Japan, Netherlands, the UK and the USA. In contrast, productivity in services grown in almost all countries.

In sum, not only productivity in services was higher than in industry for most of the countries, but it also exhibited higher growth rates over the years. These findings are at odds with the conventional wisdom that productivity in industry is higher than in services (and that it grows more), which has been supported by some well-known results from the economic growth literature.[21]

These divergences can be attributed to the fact that previous analysis were based on labor productivity comparisons between sectors (and countries), not on the contribution of all inputs. In contrast, these new stylized facts are supported by a model that quantifies the influence of all inputs over productivity.

Figure 6 shows the 3-sector TFP for Brazil, China, Netherlands, Japan, UK and USA:

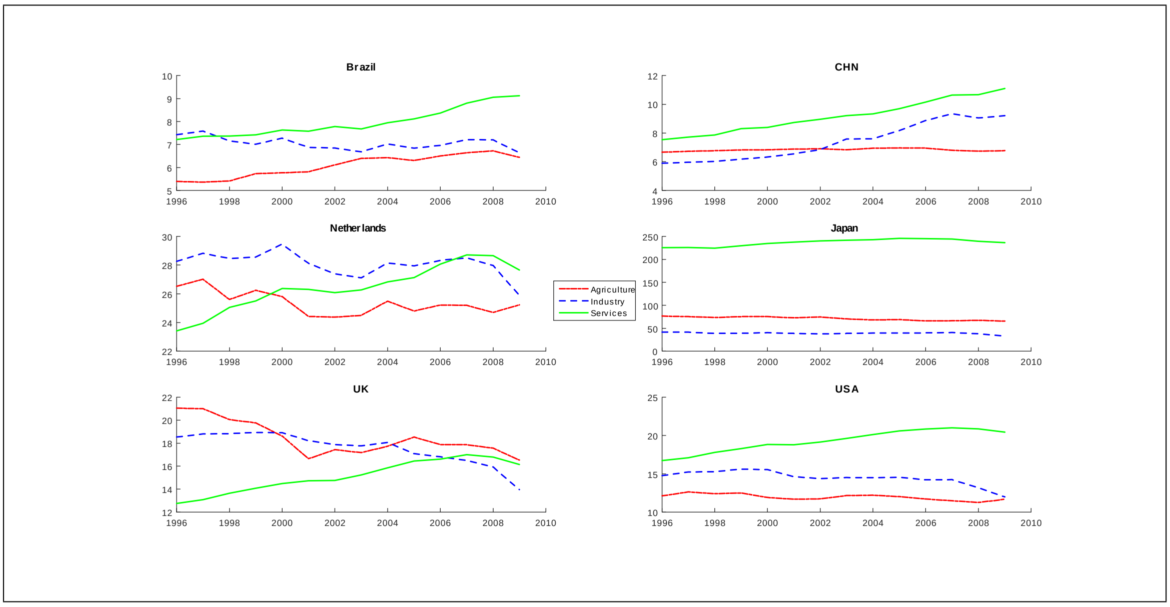


Figure 2.6: Multi-Country 3-Sector TFP Levels - Selected Countries

In summary, TFP in services has grown in all six countries under analysis. In contrast, except for China (whose TFP growth rates were positive for the three sectors), industry has

[20] These 10 countries are: Belgium, Brazil, Cyprus, Greece, Germany, Netherlands, Malta Portugal, Slovenia and the UK.

[21] See, for example, the seminal work of Baumol (1967), Baumol et al. (1985) and the most recent contributions of Duarte and Restuccia (2010), McMillan and Rodrik (2011), Ferreira and Silva (2015) and Duarte and Restuccia (2015).

experienced significant productivity losses over the period, which accounted for a convergence towards TFP in agriculture, the less efficient sector, specially in Brazil, Netherlands and the USA.

Note also that, in countries where TFP in services was already the highest at the beginning of the series, this sector has still remained as the most efficient one (see China's, Japan's and the USA's series). On the other hand, in Brazil and Netherlands, TFP's increase in services was high enough to turn this sector into the most efficient of these economies, and such path seems to be also followed by the UK's series.

Therefore, these results indicate that most of the aggregate TFP growth reported in the previous sections can be assigned to technological improvements in the services sector. [22]

2.3.5 Multi-Country 35-Activities TFP Levels

It is also interesting to investigate the activities that were directly responsible for good or bad productivity performances of each of the three sectors and, ultimately, of the countries' total factor productivities. As our conterfactuals trace hypothetical scenarios contrasting sectoral productivities of Brazil and the USA, the main goal of this section is to track the TFP paths of these two countries.[23]

The following figures provide series for the economic activities whose productivities were among the five highest and five lowest in 2009. When these activities do not coincide with the ones with highest annualized growth rates over the period, the latter are also included in the analysis.

Recall from Figure 2 that Brazil was one of the few countries in our sample in which TFP in agriculture has grown at a higher annualized rate than TFP in total economy. Also, from figure 5, note that Brazil's TFP in services has grown more than in total economy. More specifically, from 1996 to 2009, Brazilian agriculture and services sectors have grown, respectively, 1,36% and 1,81% per year. Conversely, over the same period of time, this country's industrial sector has shrink at a negative growth rate of 0,86% per year.

These opposite paths have accounted for a convergence between the productivities in agriculture and industry (see figure 6). Although TFP in industry was, in 1996, two points above TFP in agriculture, in 2009 this difference was almost insignificant (only of 0,21 points). Moreover, at the beginning of the period, the productivities in services and in industry were roughly the same. However, in the last year observed, productivity in services was already almost 40% higher than in industry.

[22] Ferreira et al. (2016) provide the 3-sector TFP levels for each country of the sample, grouped according to the mains trends of their sectoral series. One can see that this pattern repeats itself for a large number of countries.

[23] Ferreira et al. (2016) also analyze the 35-activities total factor productivities of China, Netherlands, Japan and UK.

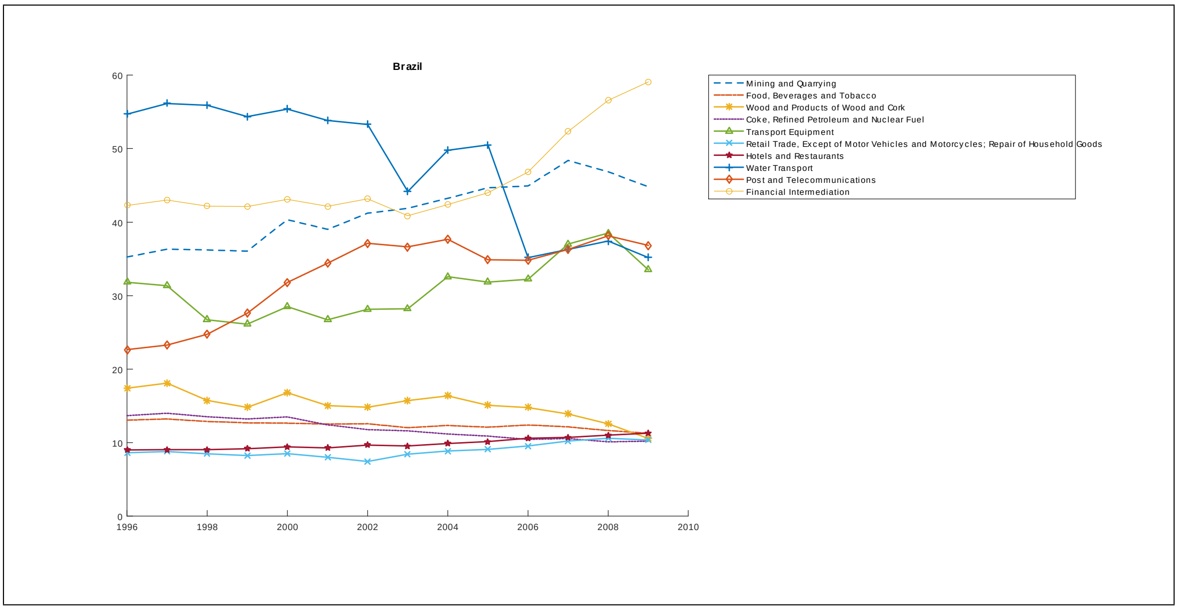


Figure 2.7: TFP Level Series: Brazil - Selected Activities

Figure 7 indicates that the good performance of brazilian services sector can be attributed to the high annual growth rates of "*Financial Intermediation*" (2,61% per year) and "*Post and Telecommunications*" (3,81% per year). Those activities also experienced a good relative performance in 2009, reaching, respectively, the second and the fourth highest productivities of the economy.

The activity with the highest productivity in 2009 was, nevertheless, "*Real Estate Activities*". This series is depicted in a separate figure (see figure 9) not only because of scale issues, but mostly due to the fact that the domestic output related to this activity - which are at the basis of our TFP results - includes the payment of rents, whose values are usually high. Therefore, TFP levels for this activity - at least the ones of the countries that adopt such accounting methodology - are likely influenced by an upward bias caused by value added distortions.

Other three activities deserve attention, namely "*Mining and Quarrying*", "*Water Transport*" and "*Transport Equipment*", for being among the highest productivity activities in 2009. It is important to emphasize the sharp productivity fall suffered by the "*Water Transport*"activity, as it was the most productive activity in 1996, but lost three positions over the period, reflected by a high negative annualized growth rate (-3,34% per year).

At the other end, "*Coke, Refined Petroleum and Nuclear Fuel*"was the activity with lowest TFP in 2009, closely followed by "*Retail Trade, Except of Motor Vehicles and Motorcycles, Repair of Household Goods*" and "*Wood and Products of Wood and Cork*". The latter was also the activity with the highest productivity losses over the period (-3,76% per year). Lastly, "*Food, Beverages and Tobacco*"and "*Hotels and Restaurants*" also presented a poor relative productivity performance.

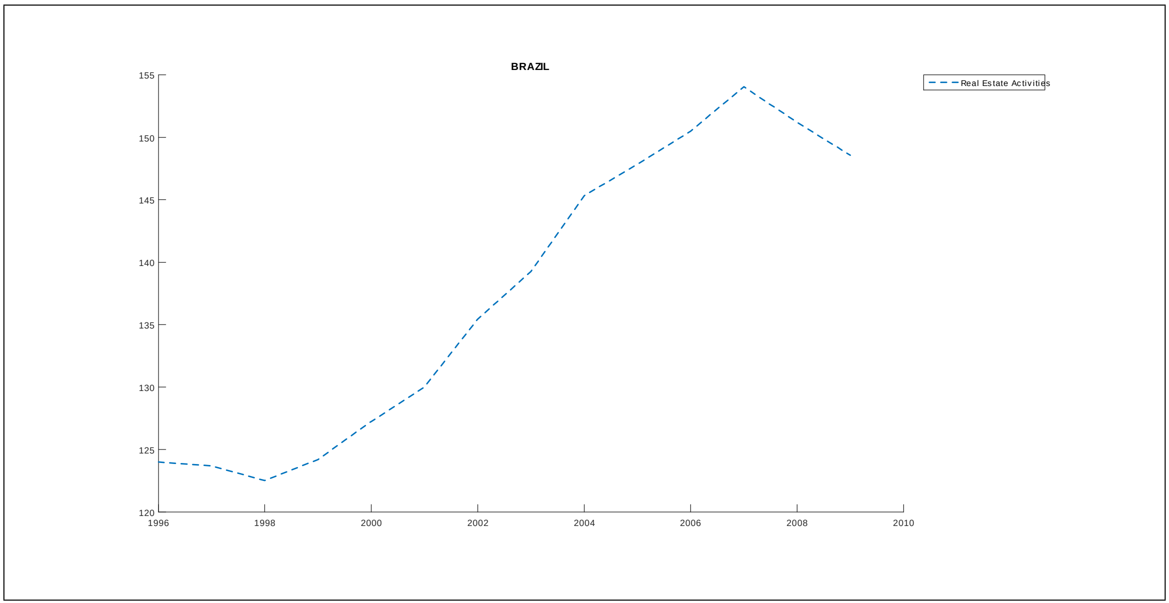


Figure 2.8: TFP Level Series: Brazil - Real Estate Activities

Similarly to the convergence observed for industry and agriculture in Brasil, USA's productivities in these activities also experienced converging paths (see figure 6). While TFP in the former sector has declined at a rate of -1,58% per year, productivity in the latter has remained virtually unchanged over the whole period. Note also that productivity growth trends in the industrial and services sector are divergent, which is, once again, analogous to what we have observed for the brazilian series. USA's TFP in services has experienced an annual productivity increase of the same absolute magnitude of the fall of its industrial productivity (+1,55% per year).

Figure 9 shows that the high annualized growth rate of productivity in services was primarily driven by *"Renting of M&Eq and Other Business Activities"* (2,30% per year) and *"Financial Intermediation"*(2,37% per year). Actually, from the highest five TPF performances, four were subgroups of services - "*Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles*", "*Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel*", "*Post and Telecommunications*"and "*Public Admin and Defence; Compulsory Social Securit*y- and one of industry, "*Electrical and Optical Equipment*".

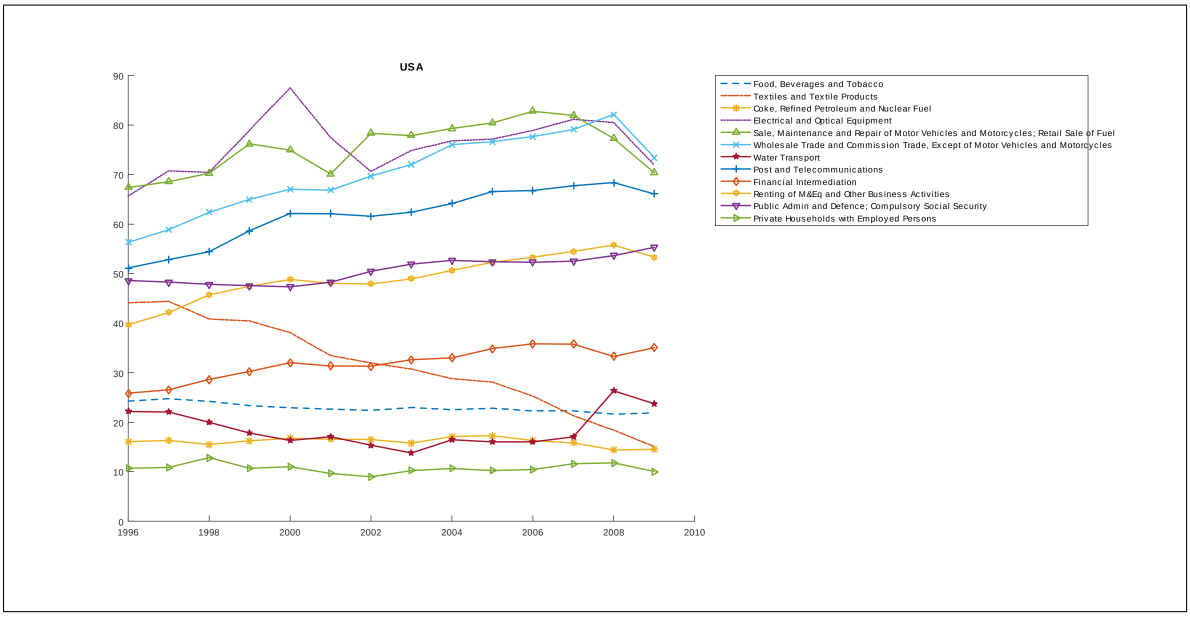


Figure 2.9: TFP Level Series: the USA - Selected Activities

However, productivity in industry was negatively influenced by the extremely low TFP levels in "*Food, Beverages and Tobacco*", "*Coke, Refined Petroleum and Nuclear Fuel*"and, especially, in "*Textiles and Textile Products*", which was the activity that obtained the lowest growth throughout the period (-7,92% per year).

Other activities belonging to the services sector did not perform well, namely "*Water Transport*"and "*Private Households with Employed Persons*", the latter being also responsible for the lowest TFP levels of the entire economy in every year of the time span.

2.4 Quantitative Analysis

In this section, we will present an in-depth comparative analysis related to patterns of sectoral and aggregate TFP's growth rates. First, we assess which sector - or sectors - contributed for the observed growth in aggregate productivity in Brazil and in the USA. Second, we perform a series of counterfactual exercises to evaluate the quantitative importance of cost shares in explaining sectoral and aggregate productivity growth.

2.4.1 Comparing growth rates of TFPs

As we noted from Figure 6, there are some similarities between the paths of sectoral productivities in Brazil and in the USA. However, when we focus on the growth rates of both sectoral and total economy productivities, some differences become clear.

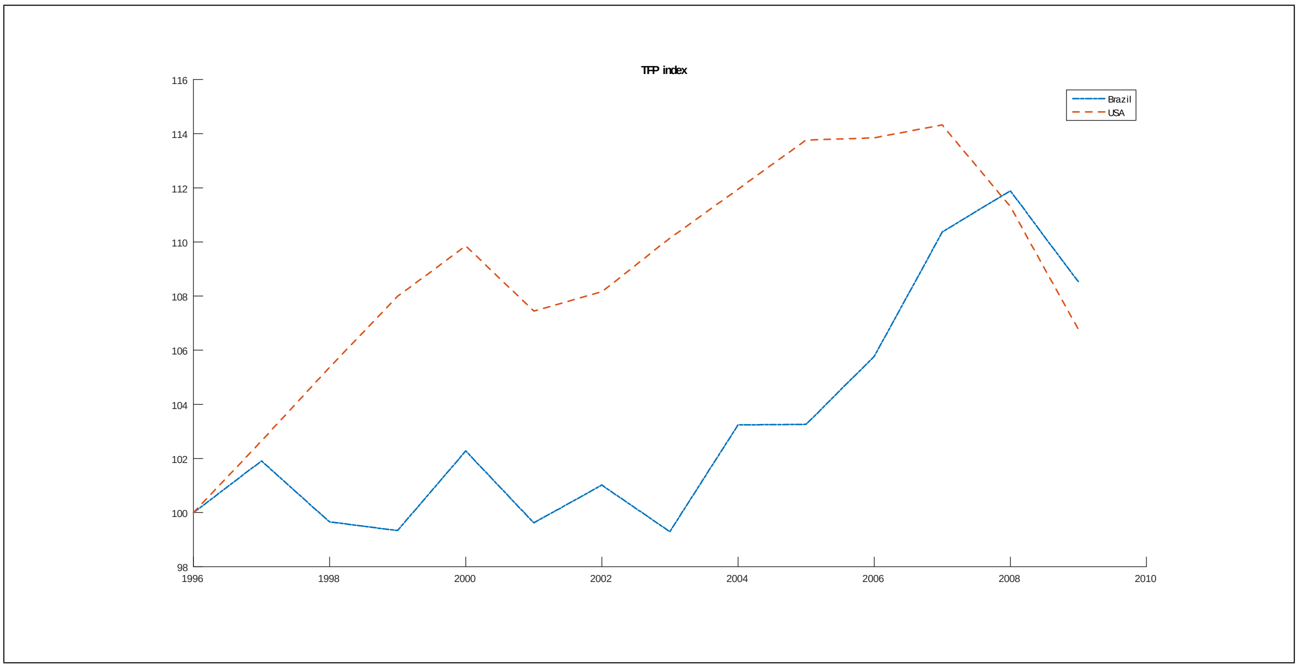


Figure 2.10: TFP Index: Total Economy - BRA vs. USA

First, Figure 10 presents total economy's TFP indices for Brazil and the USA. Note that, from the beginning of the period until 2000, while TFP in Brazil has only grown 0,57% per year, these rates in the USA were almost 5 times higher (2,38% per year). Moreover, between 2001 and 2007, TFP growth trend was continuously positive for the USA, reflecting an increase of 1,04% per year, while growth in Brazil's productivity remained extremely low until 2005 (TFP annualized growth is of 0,40% per year for 1996-2005 and 0,32% per year for 2000-2005).

However, from 2005 to 2007 this scenario has changed: productivity in the USA has almost stagnated (growing only 0,25% per year), but it expanded in Brazil at 3,38% per year. The subprime crisis then led to a sharp fall in TFP already in 2007 in the USA (-3,36% per year between 2007-2009) but its after-effects have reached brazilian economy only a year later, leading to a productivity decrease of a similar magnitude between 2008 and 2009 (-3%).

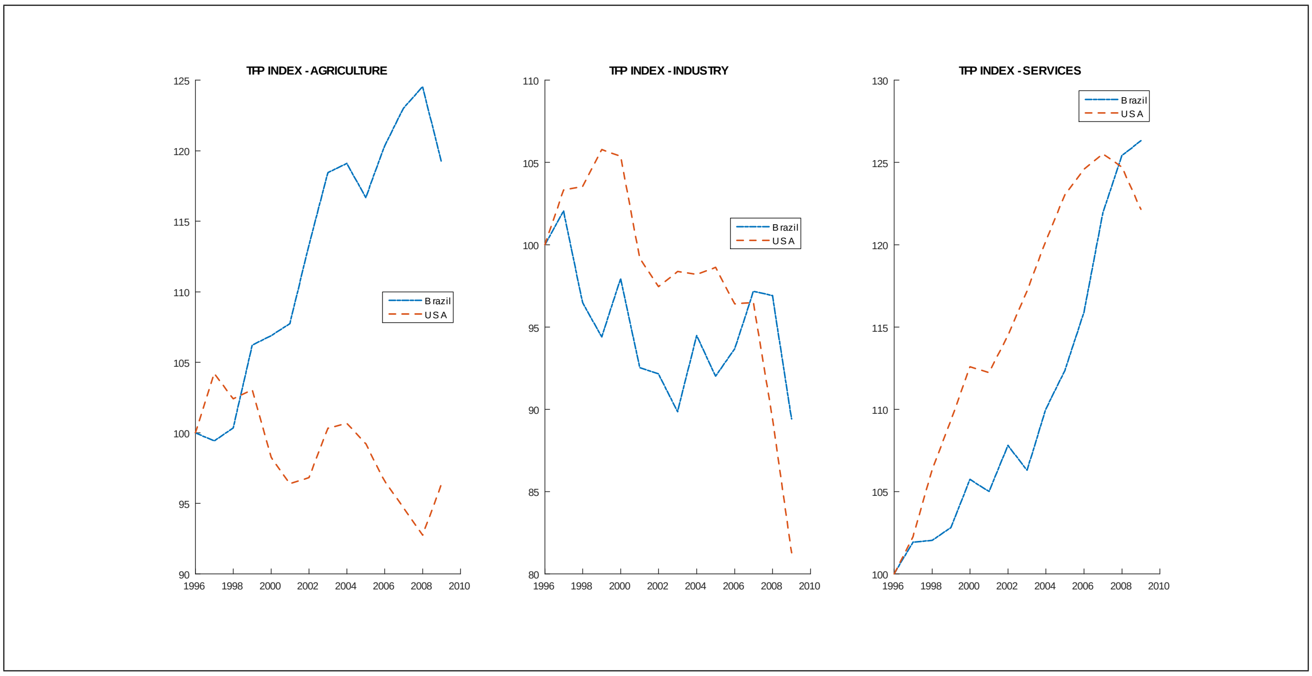


Figure 2.11: TFP Sectoral Indices: BRA vs. USA

From the left-hand chart of Figure 11, one can see that there are some clear differences between sectoral productivities in Brazil and in the USA. TFP in Agriculture has increased at the positive annualized rate of 1,36% per year in Brazil (therefore, at a higher rate than total economy, which grew 0,63% p.y.). Conversely, this sector experienced a negative growth rate in the USA (-0,28% p.y.). It is interesting to also note that, between 2008 and 2009 (i.e., during the subprime crisis' spread), while productivity in Agriculture fell 4,30% in Brazil, it increased 3,91% in the USA.

Concerning the industrial sector (see the chart in the middle of Figure 12), even if we do not take into account the marked drop in Industry's productivity, which begins in 2008, its TFP has shrinked in Brazil and the USA, respectively, 0,26% p.y. and 0,92% p.y (considering the whole period, these rates increase to 0,86% and 1,58%, respectively).

The productivity scenario is quite different for the service sector (see the right-hand chart of Figure 12), which has experienced a clear positive growth trend in both countries. Despite a few minor oscilations in the indices, there was a clear TFP boom in services during the analyzed period: it has increased 1,81% per year in Brazil, and 1,55% in the USA.

We summarize our findings in the following facts:

(1) Total factor productivity has increased both in Brazil (0,63% p.y. throughout the whole period and 0,94% p.y. until the peak in 2008) and in the USA (0,51% p.y. throughout the whole period and 1,23% p.y. until the peak in 2007);

(2) Since TFP in Agriculture is positively correlated with total economy's productivity in Brazil, but there is a negative relation between the two corresponding series for the USA (the correlation coefficients are, respectively, 0,73 and -0,49), it is likely that only in Brazil this sector has produced a positive effect over total economy's productivity;

(3) Contrary to the common sense, productivity in Industry has promoted an adverse effect over aggregate productivity in both countries;

(4) It can be observed a marked productivity boom in the service sector in Brazil and in the USA. Both series are positively and highly correlated with the corresponding aggregate productivity index in total economies (the correlation coefficients are, respectively, 0,94 and 0,89). Therefore, we argue that productivity growth in the service sector was the main driving

force for these aggregate productivity outcomes.

2.4.2 Counterfactuals

We construct a series of counterfactuals to evaluate the quantitative importance of sectoral cost shares in explaining sectoral and aggregate productivity growth.

First, recall that one of the most interesting features of the model presented on Section 2 was its capability of generating an extremely simple and intuitive equation for the dynamics of output. Letting $y_t \equiv \{\ln Y_{i,t}\}$ denote a $N \times 1$ vector of outputs, we obtained:

$$y_{t+1} = Ay_t + k + \eta_{t+1}$$

where A is the $N \times N$ matrix of parameters $\{a_{ij}\}$, k is a $N \times 1$ vector of constants and η_{t+1} is the $N \times 1$ stochastic vector $\{\ln \lambda_{i,t+1}\}$.

Rearranging (2.15), we obtain an equation for the log of the sectoral total factor productivity shocks of our model:

$$\eta_{t+1} = y_{t+1} - Ay_t - k$$

Also, observe that, by taking first-differences of the equation (2.15), we obtain a solution for the sectoral total factor productivity growth rates:

$$y_{t+1} - y_t = A(y_t - y_{t-1}) + (\eta_{t+1} - \eta_t)$$

$$\triangle\, \eta_{t+1} = \triangle y_{t+1} - A \triangle y_t \tag{2.21}$$

As our main goal is to address changes in TFPs, contrasting the counterfactual's results with the model, we only need to recalculate the TFP's growth rates. Note from these equations that sectoral TFP growth rates do not depend on the vector k. On the other hand, as we have already emphasized, the A matrix of cost shares is at the core of the mechanism that drives the propagation of productivity shocks through time and across sectors.

We are interested on assessing to what extent sectoral cost shares influence total factor productivies. We provide two sets of counterfactuals. The first and main set is focused on showing how changes on the cost shares associated with intermediate uses of domestic outputs are capable of affecting sectoral and aggregate total factor productivities. The second aims only to clarify the relevance of a country's specific choice of international trade partners - more specifically, the optimum allocation of imported inputs - for its sectoral and total economy's productivities.

We ask the following question: What happens to Brazil's sectoral and aggregate total factor productivity's growth if we substitute brazilian cost shares with the corresponding cost shares of the US economy? As we are dealing with 35 activities (which we aggregate in 3 sectors and in total economy's outcomes) and 40 countries, this broad question can narrowed in many directions, serving as a guide to a large number of counterfactual exercises.

For a example of the first set of counterfactuals, we aim to assess how Brazil's TFP in industry changes if we replace brazilian industry's cost shares relative to inputs belonging to the service sector by the corresponding cost shares of the US economy. We restrict these changes to affect only the cost shares associated with intermediate uses of domestic output. For the second set of counterfactuals, we ask this question again, but we do not impose any restrictions: all corresponding cost shares are exposed to these changes, i.e., either the ones associated with intermediate uses of domestic output or the ones associated with intermediate uses of imported outputs.

We perform 6 counterfactuals, 3 on each set of analysis. But before presenting them, a 3x3 example - referring to an economy environment populated only by 3 countries and 3 sectors - may help elucidating the strategy we used for constructing our hypothetical scenarios.

First, Table 1 depicts a WIOT schematic outline for a given year t in this economy:[24]

[24] There are three main differences between this schematic WIOT and the originaly provided by the WIOD: First, we actually illustrate a transpose WIOT, to match our notation. Second, the WIOTs are divided into two major blocks: "intermediate uses"and "final uses". The row whose entries are the total consumption of each produced commodity represent the final uses block of the WIOT. Third, the WIOTs do not provide information on labor input for each activity, but the SEAs does. Total costs are also included in our WIOT only for didactic matters.

Table 2.1: WIOT schematic outline

country	sector	A	A	A	B	B	B	C	C	C	$TIC_i=$	L_i	TC_i
		1	2	3	1	2	3	1	2	3	$=\sum_j X_{i,j}$	-	-
A	1	$X_{1A,1A}$	$X_{1A,2A}$	$X_{1A,3A}$	$X_{1A,1B}$	$X_{1A,2B}$	$X_{1A,3B}$	$X_{1A,1C}$	$X_{1A,2C}$	$X_{1A,3C}$	$\sum_j X_{1A,j}$	L_{1A}	TC_{1A}
A	2	$X_{2A,1A}$	$X_{2A,2A}$	$X_{2A,3A}$	$X_{2A,1B}$	$X_{2A,2B}$	$X_{2A,3B}$	$X_{2A,1C}$	$X_{2A,2C}$	$X_{2A,3C}$	$\sum_j X_{2A,j}$	L_{2A}	TC_{2A}
A	3	$X_{3A,1A}$	$X_{3A,2A}$	$X_{3A,3A}$	$X_{3A,1B}$	$X_{3A,2B}$	$X_{3A,3B}$	$X_{3A,1C}$	$X_{3A,2C}$	$X_{3A,3C}$	$\sum_j X_{3A,j}$	L_{3A}	TC_{3A}
B	1	$X_{1B,1A}$	$X_{1B,2A}$	$X_{1B,3A}$	$X_{1B,1B}$	$X_{1B,2B}$	$X_{1B,3B}$	$X_{1B,1C}$	$X_{1B,2C}$	$X_{1B,3C}$	$\sum_j X_{1B,j}$	L_{1B}	TC_{1B}
B	2	$X_{2B,1A}$	$X_{2B,2A}$	$X_{2B,3A}$	$X_{2B,1B}$	$X_{2B,2B}$	$X_{2B,3B}$	$X_{2B,1C}$	$X_{2B,2C}$	$X_{2B,3C}$	$\sum_j X_{2B,j}$	L_{2B}	TC_{2B}
B	3	$X_{3B,1A}$	$X_{3B,2A}$	$X_{3B,3A}$	$X_{3B,1B}$	$X_{3B,2B}$	$X_{3B,3B}$	$X_{3B,1C}$	$X_{3B,2C}$	$X_{3B,3C}$	$\sum_j X_{3B,j}$	L_{3B}	TC_{3B}
C	1	$X_{1C,1A}$	$X_{1C,2A}$	$X_{1C,3A}$	$X_{1C,1B}$	$X_{1C,2B}$	$X_{1C,3B}$	$X_{1C,1C}$	$X_{1C,2C}$	$X_{1C,3C}$	$\sum_j X_{1C,j}$	L_{1C}	TC_{1C}
C	2	$X_{2C,1A}$	$X_{2C,2A}$	$X_{2C,3A}$	$X_{2C,1B}$	$X_{2C,2B}$	$X_{2C,3B}$	$X_{2C,1C}$	$X_{2C,2C}$	$X_{2C,3C}$	$\sum_j X_{2C,j}$	L_{2C}	TC_{2C}
C	3	$X_{3C,1A}$	$X_{3C,2A}$	$X_{3C,3A}$	$X_{3C,1B}$	$X_{3C,2B}$	$X_{3C,3B}$	$X_{3C,1C}$	$X_{3C,2C}$	$X_{3C,3C}$	$\sum_j X_{3C,j}$	L_{3C}	TC_{3C}
$\sum_i X_{i,j}$		$\sum_i X_{i,1A}$	$\sum_i X_{i,2A}$	$\sum_i X_{i,3A}$	$\sum_i X_{i,1B}$	$\sum_i X_{i,2B}$	$\sum_i X_{i,3B}$	$\sum_i X_{i,1C}$	$\sum_i X_{i,2C}$	$\sum_i X_{i,3C}$			
C_j		C_{1A}	C_{2A}	C_{3A}	C_{1B}	C_{2B}	C_{3B}	C_{1C}	C_{2C}	C_{3C}			
Y_j		Y_{1A}	Y_{2A}	Y_{3A}	Y_{1B}	Y_{2B}	Y_{3B}	Y_{1C}	Y_{2C}	Y_{3C}			

Suppose there are 3 countries, A,B and C, and three sectors, 1, 2 and 3, each producing a single specific commodity, which results in 9 different commodities which may differ due to the sector they are listed on and/or their country of origin, $i \in I = \{1A, 2A, 3A, 1B, 2B, 3B, 1C, 2C, 3C\}$. This 14x14 input-output table (including the indices) must be read as follows:

The entries belonging to rows and colunms 3 through 11 compose the intermediate uses (or intermediate consumption) block of our WIOT. A given row i of the table presents the value of all commodity inputs (columns 3 to 11) and labor inputs (column 13) that are combined for the production of the commodity output i, produced by the country and sector specified, respectively, on the 1st and 2nd columns of the corresponding row. For exemple, the element $X_{1B,3A}$ represents the amount of commodity 3A (of sector 3 produced in country A) imported by country B for the production of the commodity 1B (of sector 1 produced in country B), and the element L_{1B} represents the total amount spent with labor - alternatively, the labor compensation - for the production of commodity 1B.

Each entry of the 12th column informs the total intermediate consumption (TIC_i) related to the production of the corresponding commodity i, i.e., the sum of (the value of) all intermediate inputs j used in the production of the corresponding commodity i (caracterized by the 1st and 2nd entries of the corresponding row). Analogously, each entry of the 13th column informs the total (value) of labor input allocated in the production of commodity i. Therefore, column 14th gives us the total production costs (TC_i) for each commodity i, which is the sum, for the corresponding line, of the 12th and 13th entries.

Accordingly, each entry of the 12th row provides the sum of all intermediate uses of the corresponding commodity j (featured by the 1st and 2nd entries of the corresponding column). Recall from the model's commodity allocation constraint (equation (2.6)) that the total amount of a commodity j (produced at year t), Y_j, must be allocated either as a input in the production of other commodities i (and even in its own production), $\mathrm{X}_{i,j}$, or to final consumption, C_j. The amount of each commodity j allocated to final consumption is given by the 13th row of the table. Therefore, row 14th gives us the (value of) total output of commodity j produced in our economy at time t, which is the sum, for each column, of its 12th and 13th entries.

Table 2 presents the outline of the A matrix of cost shares for a given year t, constructed from the elements of the WIOT.

Table 2.2: A matrix schematic outline

country	sector	A 1	A 2	A 3	B 1	B 2	B 3	C 1	C 2	C 3	capital intensity	labor intensity
A	1	$a_{1A,1A}$	$a_{1A,2A}$	$a_{1A,3A}$	$a_{1A,1B}$	$a_{1A,2B}$	$a_{1A,3B}$	$a_{1A,1C}$	$a_{1A,2C}$	$a_{1A,3C}$	$\sum_j a_{1A,j}$	b_{1A}
A	2	$a_{2A,1A}$	$a_{2A,2A}$	$a_{2A,3A}$	$a_{2A,1B}$	$a_{2A,2B}$	$a_{2A,3B}$	$a_{2A,1C}$	$a_{2A,2C}$	$a_{2A,3C}$	$\sum_j a_{2A,j}$	b_{2A}
A	3	$a_{3A,1A}$	$a_{3A,2A}$	$a_{3A,3A}$	$a_{3A,1B}$	$a_{3A,2B}$	$a_{3A,3B}$	$a_{3A,1C}$	$a_{3A,2C}$	$a_{3A,3C}$	$\sum_j a_{3A,j}$	b_{3A}
B	1	$a_{1B,1A}$	$a_{1B,2A}$	$a_{1B,3A}$	$a_{1B,1B}$	$a_{1B,2B}$	$a_{1B,3B}$	$a_{1B,1C}$	$a_{1B,2C}$	$a_{1B,3C}$	$\sum_j a_{1B,j}$	b_{1B}
B	2	$a_{2B,1A}$	$a_{2B,2A}$	$a_{2B,3A}$	$a_{2B,1B}$	$a_{2B,2B}$	$a_{2B,3B}$	$a_{2B,1C}$	$a_{2B,2C}$	$a_{2B,3C}$	$\sum_j a_{2B,j}$	b_{2B}
B	3	$a_{3B,1A}$	$a_{3B,2A}$	$a_{3B,3A}$	$a_{3B,1B}$	$a_{3B,2B}$	$a_{3B,3B}$	$a_{3B,1C}$	$a_{3B,2C}$	$a_{3B,3C}$	$\sum_j a_{3B,j}$	b_{3B}
C	1	$a_{1C,1A}$	$a_{1C,2A}$	$a_{1C,3A}$	$a_{1C,1B}$	$a_{1C,2B}$	$a_{1C,3B}$	$a_{1C,1C}$	$a_{1C,2C}$	$a_{1C,3C}$	$\sum_j a_{1C,j}$	b_{1C}
C	2	$a_{2C,1A}$	$a_{2C,2A}$	$a_{2C,3A}$	$a_{2C,1B}$	$a_{2C,2B}$	$a_{2C,3B}$	$a_{2C,1C}$	$a_{2C,2C}$	$a_{2C,3C}$	$\sum_j a_{2C,j}$	b_{2C}
C	3	$a_{3C,1A}$	$a_{3C,2A}$	$a_{3C,3A}$	$a_{3C,1B}$	$a_{3C,2B}$	$a_{3C,3B}$	$a_{3C,1C}$	$a_{3C,2C}$	$a_{3C,3C}$	$\sum_j a_{3C,j}$	b_{3C}

To clarify the identification strategy we apply to obtain each element of this matrix, we need to recall two features of these WIOTs. First, from equation (2.19) we emphasized that, due to the hypothesis of constant returns to scale, the elements of the A matrix[25] are the equilibrium cost shares, i.e., a_{ij} is the equilibrium share of input j in the cost of output i.

Therefore, to construct this matrix, we need to evaluate the cost share of an input in the production of a output, for all pairs of activities. Second, note that as the WIOT is valuated at basic prices - i.e., all values in their intermediate and final use blocks represent the amount receivable by the producer from the purchaser - its elements already inform the value of our variables of interest[26], so that we can rewrite equation (2.19) as:

$$\begin{aligned} a_{ij} &= \frac{X^*_{ij,t}}{L^*_{i,t} + \sum_{k=1}^{N} X^*_{ik,t}} \\ &= \frac{X^*_{ij,t}}{TC^*_{i,t}} \end{aligned} \tag{2.22}$$

Hence, to obtain each element a_{ij} of the A matrix of cost shares, we only have to divide the i, j-th element of the intermediate uses block - which corresponds to the cost of input j in the production of output i ($X^*_{ij,t}$) - by the sum of the labor compensation ($L^*_{i,t}$) and of the total intermediate consumption ($\sum_{k=1}^{N} X^*_{ik,t}$) of commodity inputs, i.e, the total costs for producing i.

Proceeding in this way for every i, j pair we obtain a 9×9 matrix of cost shares. Recall that the sum of all the elements that compound a given row of the A matrix must be equal to one minus labor's cost shares, and, for this reason, it is appropriate to say that it measures the capital intensity of the corresponding sector:

$$\sum_{j=1}^{J} a_{ij} = 1 - b_i$$

Since the WIOD covers 15 years (1995-2009), we actually construct 15 of these matrices, one for each year available, and work with an averaged matrix.

Intermediate uses of domestic outputs, cost shares and TFPs (C1)

This first and main set of counterfactuals aims to assess to what extent changes on the cost shares associated with intermediate uses of **domestic** outputs affect sectoral and aggregate total factor productivities.

The following question guides this section's counterfactual exercises: What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we substitute brazilian cost shares - but only the ones (i) associated with a given sector's intermediate use of domestic outputs and (ii) produced by another (or the same) given sector - by the corresponding cost shares of the US economy?

A example using the WIOT and matrix A schematic outline we described may help clarify these exercises. Suppose we aim to assess how TFP changes in country A if we replace this country's share of sector 3's input in the cost of sector 1's output by the corresponding cost shares

[25] Also, recall that, by construction, the elements of the A matrix are the elasticities of commodity outputs with respect to commodity inputs.

[26] The WIOTs are valued in US dollars.

of country B. Moreover, we restrict these changes to affect only the cost shares associated with intermediate uses of **domestic** outputs, preserving the cost shares associated with intermediate uses of imported inputs unchanged.

Table 3 replicates only the rows of Table 2 we need to analyze. In the proposed counterfactual exercise, we replace the cost share $a_{1A,3A}$ with $a_{1B,3B}$. I.e., after the appropriate substitution, $a'_{1A,3A} = a_{1B,3B}$. Note that, as we restrict the changes only to intermediate uses of **domestic** outputs, country A's shares of sector 3's input in the cost of sector 1's output associated with intermediate uses of **imported** outputs, $a_{1A,3B}$ and $a_{1A,3C}$ remain unchanged.

Table 2.3: Modified A matrix - Counterfactual 1

country		A	A	A	B	B	B	C	C	C
	sector	1	2	3	1	2	3	1	2	3
A	1	$a_{1A,1A}$	$a_{1A,2A}$	$\boxed{a_{1B,3B}}$	$a_{1A,1B}$	$a_{1A,2B}$	$a_{1A,3B}$	$a_{1A,1C}$	$a_{1A,2C}$	$a_{1A,3C}$
A	2	.	.	.	.	.	.	.	.	.
A	3	.	.	.	.	.	.	.	.	.
B	1	$a_{1B,1A}$	$a_{1B,2A}$	$a_{1B,3A}$	$a_{1B,1B}$	$a_{1B,2B}$	$\boxed{a_{1B,3B}}$	$a_{1B,1C}$	$a_{1B,2C}$	$a_{1B,3C}$
B	2	.	.	.	.	.	.	.	.	.
B	3	.	.	.	.	.	.	.	.	.
C	1	.	.	.	.	.	.	.	.	.
C	2	.	.	.	.	.	.	.	.	.
C	3	.	.	.	.	.	.	.	.	.

The challenge we face is to impose this changes to the cost shares while still preserving the consistence of our general equilibrium framework. We cannot, for instance, substitute these cost shares directly on the A matrix and suppose sectoral outputs remain unchanged.

Actually, note from Tables 2 and 3 and from (2.22) that all elements of a given row of the A matrix refer to shares of the corresponding commodity inputs in the cost of producing that row's specific commodity output, i.e., they are based on the same total cost of producing a given commodity. Therefore, if we intend to change the cost share $a_{1A,3A}$, and only this entry of matrix A, we have to, actually, change the value of the intermediate domestic input accordingly (and keep the value of total cost intact).

Rearranging (2.22), we obtain the proper modified values of $X_{1A,3A}$ for each time t:

$$X'_{1A,3A,t} = a'_{1A,3A} \times TC^{*}_{1A,t} \quad (2.23)$$

$$= a_{1B,3B} \times TC^{*}_{1A,t} \quad (2.24)$$

Table 2.4: Modified WIOT - Counterfactual 1

country		A	A	A	B	B	B	C	C	C	TIC_i	L_i	TC_i
	sector	1	2	3	1	2	3	1	2	3			
A	1	$X_{1A,1A}$	$X_{1A,2A}$	$\mathbf{X}'_{1A,3A}$	$X_{1A,1B}$	$X_{1A,2B}$	$X_{1A,3B}$	$X_{1A,1C}$	$X_{1A,2C}$	$X_{1A,3C}$	$\sum_j \mathbf{X}_{1A,j}$	$\mathbf{L}_{1A}$	TC_{1A}
A	2	.	.	$X_{2A,3A}$	.	.	.	.	.	.	.	.	.
A	3	.	.	$X_{3A,3A}$	.	.	.	.	.	.	.	.	.
B	1	.	.	$X_{1B,3A}$	.	.	.	.	.	.	.	.	.
B	2	.	.	$X_{2B,3A}$	.	.	.	.	.	.	.	.	.
B	3	.	.	$X_{3B,3A}$	.	.	.	.	.	.	.	.	.
C	1	.	.	$X_{1C,3A}$	.	.	.	.	.	.	.	.	.
C	2	.	.	$X_{2C,3A}$	.	.	.	.	.	.	.	.	.
C	3	.	.	$X_{3C,3A}$	.	.	.	.	.	.	.	.	.
$\sum_i X_{i,j}$		.	.	$\sum_i \mathbf{X}_{i,3A}$	.	.	.	.	.	.			
C_j		.	.	C_{3A}	.	.	.	.	.	.			
Y_j		.	.	$\mathbf{Y}_{3A}$	.	.	.	.	.	.			

Note that the new WIOTs, for all time t, will differ from the original tables by five entries: the value of $\mathbf{X}'_{1A,3A}$ itself and, thereafter, the values of $\sum_i \mathbf{X}_{i,3A}$, $\mathbf{Y}_{3A}$, $TIC_{1A} = \sum_j \mathbf{X}_{1A,j}$ and $\mathbf{L}_{1A}$. The consequences for our equilibrium quantities are summarized as follows:

(1) When the value of the intermediate use of the domestic output $\mathbf{X}_{1A,3A}$ changes at time t, the total output of commodity 3A at t also changes, according to the commodity constraint .$Y_{3A,t} = C_{3A,t} + \sum_{i=1}^{N} X_{3Aj,t}$. Also, recall from the equation for the dynamics,

$$y_{i,t+1} = \sum_{j=1}^{N} a_{ij} y_{j.t} + k_i + \eta_{i,t+1}$$

that the equilibrium quantities of all outputs that use commodity 3A as an input at $t+1$ will also change, which causes the outputs of the commodities that use this modified outputs as inputs in $t+2$ to change accordingly, and so on. Therefore, the values we calculate for total factor productivity will also change at all time t.

(2) As we intend to change the cost share $a_{1A,3A}$, and only this cost share, the total production costs of commodity 1A cannot change. For this to be possible, as total intermediate consumption $\left(TIC_{1A} = \sum_j \mathbf{X}_{1A,j}\right)$ changes directly with shifts in $\mathbf{X}_{1A,3A}$, it is necessary that $\mathbf{L}_{1A}$ changes in the opposite direction, so as to keep total costs TC_{1A} constant.

For each counterfactual, we obtain 15 new WIOTs (one for each year of the database). From these WIOTs, we recalculate A matrix of cost shares and obtain 15 new series of total output. We then use these counterfactual series to calculate the hypothetical total factor productivity indices, and contrast each of them with the original "observed" series (i.e., constructed from original data). [27]

The three counterfactual exercises we perform in this section aim to answer the following questions:

(C1.1)What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of its **domestic services** in the total cost of its **industry** by the corresponding cost shares of the US economy?

(C1.2) What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of its **domestic industry** in the total cost of its **industry** by the corresponding cost shares of the US economy?

(C1.3) What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of all of its **domestic sectors** in the total cost of its **industry** by the corresponding cost shares of the US economy?

Table 5 provides a guide to all exercises we perform in this paper. The letter "A"assigned to some of the counterfactuals indicates that most of their outcomes are presented only in Appendix 2.

[27] An observation must be made before we present our counterfactuals' results, concerning the aggregation of the data. We adopted the same approach of Ferreira et al. (2016) when constructing the original series of TFP (from the data). Therefore, the first products of each exercise are 1400 series (for 35 activities and 40 countries) of multi-country 35-activity TFP indices, denominated in constant (national currencies. After obtaining these sectoral series, the 35 activities are aggregated into 3 - agriculture, industry and services - according to correspondence depicted on Table A.1, presented in Appendix. The aggregation is always conducted at the levels of the intermediate consumption, gross output and labor compensation. Only then we calculate the growth rates of sectoral TFP.

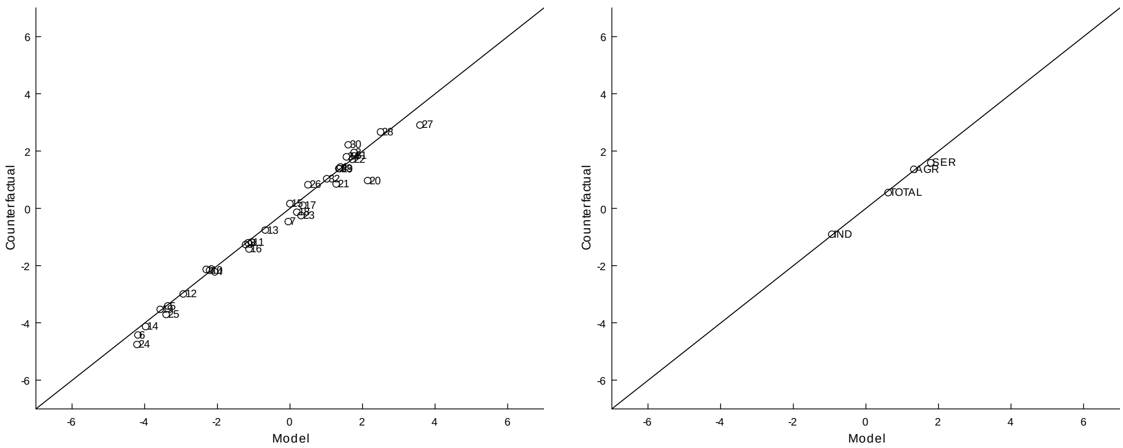
After aggregating the 35 activities into three sectors, the A matrix become of order 120×120. This new exercise provides 120 series (related to 3 sectors and 40 countries) of multi-country sectoral TFP indices, denominated in national currencies. Finally, the series are once again aggregated to country-levels, resulting on 40 series of total economy's TFP.

Table 2.5: Counterfactual's guide

COUNTERFACTUALS - What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if:	
GROUP 1	The shares of Brazil's domestic ( ) are replaced by the corresponding cost shares of the US economy
C1.1	services in the total cost of its industry
C1.2	industry in the total cost of its industry
C1.3	all sectors in the total cost of its industry
C1.4 (A)	services in the total cost of its manufacturing
C1.5 (A)	manufacturing in the total cost of its manufacturing
C1.6 (A)	all sectors in the total cost of its manufacturing
GROUP 2	The shares of Brazil's ( ) are replaced by the corresponding cost shares of the US economy
C2.1	services in the total cost of its industry
C2.2	industry in the total cost of its industry
C2.3	all sectors in the total cost of its industry
C2.4 (A)	services in the total cost of its manufacturing
C2.5 (A)	manufacturing in the total cost of its manufacturing
C2.6 (A)	all sectors in the total cost of its manufacturing

Results Figures 12, 13 and 14 summarize the results of these exercises. Each panel on the left-hand side plots, for the corresponding counterfactual, the annualized growth rates of TFP in each of Brazil's economic activities[28], in the model and in the counterfactual. The right-hand side panels show, for each counterfactual, the annualized growth rates of TFP in Brazil's agriculture, industry and services, as well as the results for the total economy, in the model and in the counterfactual.

Figure 12 shows the results of counterfactual C1.1, which replaces the shares of Brazil's **domestic services** in the total cost of its **industry** by the corresponding cost shares of the US economy. Tables 4, 5 and 6 report the summary statistics for this exercise.



(C1.1) 35 Activities

(C1.1) 3-Sector and Total

Figure 2.12: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C1.1

Note from the left hand side panel that TFP's growth rates are higher in the counterfactual than in the model for 14 out of 34 activities[29], 9 of them belonging to the service sector. Among industrial activities, TFP's growth increases specially in "(#2) Mining and Quarrying "(11,67%), and in "(#8) Coke, Refined Petroleum and Nuclear Fuel" (7,01%). We also emphasize that to all 4 industrial activities that experienced gains in TFP growth were assigned higher labor intensities, as a direct consequence of the replacement of the cost shares (see Table 7).[30]In fact, labor intensities are higher in the counterfactual for only 6 of the 17 industrial activities.

The right hand side panel of Figure 12 (and Table 8) show that services is the only sector to present a lower TFP's growth rate in the counterfactual than in the model, nevertheless experencing a decrease of almost 10%. Note also that the annualized growth rates of productivity

[28] Reflecting TFP growth observed for the period 1996-2009.

[29] We do not have data for the activity "Private Households with Employed Persons"in Brazil, so we ommit this activity from the calculations. The activities are numbered following the classification of Table A.1 in Appendix 1.

[30] Recall from the model that the labor's cost shares in a activity i is given by $b_i = 1 - \sum_{j=1}^{J} a_{ij}$, i.e., one minus the capital intensity in activity i, and so it measures the labor intensity of the corresponding activity. Therefore, when some a_{ij} change, the capital and labor intensities in activity i also change.

for the total economy are almost 9% lower in the counterfactual than in the model, showing that higher TFP's growths in agriculture and industry could not compensate the sharp fall in the service sector. Also, as we can see in Table 8, labor intensities in industry and in total economy are, respecively, 7,49% and 1,90% lower in the counterfactual than in the model.

Table 2.6: Annualized growth rates of TFP in Brazil's economic activities - C1.1

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,44	3,29
Mining and Quarrying	2	1,76	1,96	11,67
Food, Beverages and Tobacco	3	-1,16	-1,21	-3,73
Textiles and Textile Products	4	-2,06	-2,21	-7,24
Leather, Leather and Footwear	5	-3,36	-3,42	-1,76
Wood and Products of Wood and Cork	6	-4,20	-4,44	-5,69
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,46	-896,92
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,14	7,01
Chemicals and Chemical Products	9	-1,23	-1,26	-2,37
Rubber and Plastics	10	-2,21	-2,17	1,82
Other Non-Metallic Mineral	11	-1,07	-1,19	-11,35
Basic Metals and Fabricated Metal	12	-2,93	-2,99	-2,07
Machinery, Nec	13	-0,68	-0,77	-13,03
Electrical and Optical Equipment	14	-3,99	-4,12	-3,38
Transport Equipment	15	0,00	0,16	5232,21
Manufacturing, Nec; Recycling	16	-1,14	-1,43	-25,10
Electricity, Gas and Water Supply	17	0,36	0,11	-69,70
Construction	18	0,19	-0,13	-32,94
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,53	1,33
Wholesale Trade and Commission Trade (...)	20	2,14	0,96	-55,37
Retail Trade, Except of Motor Vehicles (...)	21	1,28	0,85	-33,55
Hotels and Restaurants	22	1,72	1,71	-0,71
Inland Transport	23	0,32	-0,25	-21,72
Water Transport	24	-4,22	-4,74	-12,51
Air Transport	25	-3,41	-3,71	-8,86
Other Supporting and Auxiliary Transport (...)	26	0,50	0,82	65,60
Post and Telecommunications	27	3,58	2,91	-18,58
Financial Intermediation	28	2,49	2,67	7,10
Real Estate Activities	29	1,37	1,37	0,00
Renting of M Eq and Other (...)	30	1,60	2,22	38,46
Public Admin and Defence; (...)	31	1,76	1,85	4,97
Education	32	1,01	1,02	0,95
Health and Social Work	33	1,35	1,38	2,15
Other Community, Social and Personal (...)	34	1,54	1,82	17,62

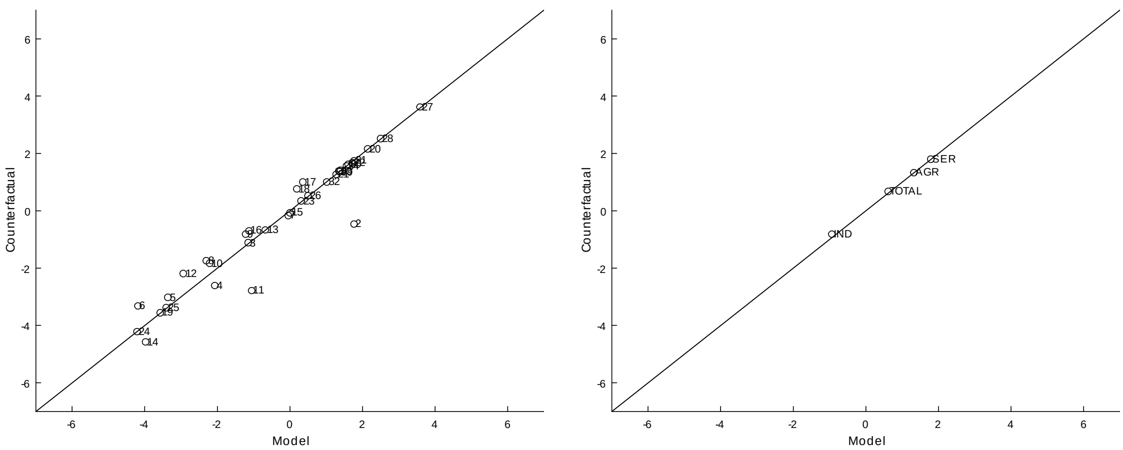
Table 2.7: Capital and labor intensities in Brazil's economic activities - C1.1

		Capital Intensity			Labor Intensity		
Activity		model	counterf	%	model	counterf	%
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,72	-11,23	0,19	0,28	47,23
Food, Beverages and Tobacco	3	0,87	0,87	0,46	0,13	0,13	-3,07
Textiles and Textile Products	4	0,69	0,72	4,09	0,31	0,28	-9,25
Leather, Leather and Footwear	5	0,75	0,75	-0,10	0,25	0,25	0,30
Wood and Products of Wood and Cork	6	0,68	0,75	10,02	0,32	0,25	-21,73
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,83	13,43	0,27	0,17	-36,98
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,90	-5,25	0,05	0,10	101,03
Chemicals and Chemical Products	9	0,82	0,82	-0,88	0,18	0,18	4,13
Rubber and Plastics	10	0,77	0,75	-3,03	0,23	0,25	10,26
Other Non-Metallic Mineral	11	0,72	0,76	5,16	0,28	0,24	-13,24
Basic Metals and Fabricated Metal	12	0,79	0,81	2,06	0,21	0,19	-7,82
Machinery, Nec	13	0,74	0,76	2,32	0,26	0,24	-6,58
Electrical and Optical Equipment	14	0,81	0,83	2,22	0,19	0,17	-9,33
Transport Equipment	15	0,82	0,76	-6,46	0,18	0,24	28,66
Manufacturing, Nec; Recycling	16	0,72	0,79	9,26	0,28	0,21	-23,95
Electricity, Gas and Water Supply	17	0,72	0,81	12,91	0,28	0,19	-33,12
Construction	18	0,65	0,75	15,27	0,35	0,25	-27,99
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.8: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.1

	annual growth			capital intensity			labor intensity		
	model	counter	change (%)	model	counter	change (%)	model	counter	change (%)
Agriculture	1,31	1,36	3,19	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,92	1,77	0,79	0,80	2,00	0,21	0,20	-7,49
Services	1,78	1,61	-9,97	0,47	0,47	0,00	0,53	0,53	0,00
Total Economy	0,60	0,55	-8,74	0,62	0,63	1,16	0,38	0,37	-1,90

Figure 13 plots the results of counterfactual C1.2, and its summary statistics are reported by Tables 9, 10 and 11. After we replace the shares of Brazil's **domestic** industry in the total cost of its **industry** by the corresponding cost shares of the US economy, TFP's growth rates increase in 23 activities.



(C1.2) 35 Activities (C1.2) 3-Sector and Total

Figure 2.13: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C1.2

Of the 16 activities assigned to the service sector, 11 present productivity improvements in the hypothetical scenario, including "(#23) Inland Transport"(6,97%) and "(#26) Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies"(4,85%). Concerning industrial activities, the higher gains of TFP's growth rates are observed in "(#17) Electricity, Gas and Water Supply"(176,58%) and in "(#18) Construction"(298,50%), activities, i.e., in the sectors of Public Utilities and Construction[31] (see Table 9).

TFP also grows more in 11 out of the 17 industrial activities, and in 10 of them were assigned higher labor shares (see table 10). The exception is "(#3) Food, Beverages and Tobacco, where labor intensity falls almost 74%.

Note from Table 11 and the right hand side of Figure 13 that TFP grows more in the counterfactual than in the model in all three sectors and in total economy. The negative TFP growth in industry is reduced in almost 13% and TFP's growths in agriculture, services and total economy increase, respectively, 1,85%, 0,72% and 12,90%. Although still highly intensive in capital (79% in the model and 74% in the counterfactual) industry's labor share is 23% higher in the counterfactual than in the model. In total economy, labor intensity increases from 38% to 40%.

[31] Following the 10-Sector Classification.

Table 2.9: Annualized growth rates of TFP in Brazil's economic activities - C1.2

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,40	0,70
Mining and Quarrying	2	1,76	-0,45	-74,48
Food, Beverages and Tobacco	3	-1,16	-1,13	3,09
Textiles and Textile Products	4	-2,06	-2,61	-26,55
Leather, Leather and Footwear	5	-3,36	-3,04	9,55
Wood and Products of Wood and Cork	6	-4,20	-3,32	20,93
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,16	-237,66
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-1,74	24,19
Chemicals and Chemical Products	9	-1,23	-0,82	33,16
Rubber and Plastics	10	-2,21	-1,85	16,62
Other Non-Metallic Mineral	11	-1,07	-2,78	-160,39
Basic Metals and Fabricated Metal	12	-2,93	-2,19	25,19
Machinery, Nec	13	-0,68	-0,66	2,71
Electrical and Optical Equipment	14	-3,99	-4,58	-14,95
Transport Equipment	15	0,00	-0,06	-1841,39
Manufacturing, Nec; Recycling	16	-1,14	-0,69	39,76
Electricity, Gas and Water Supply	17	0,36	0,99	176,58
Construction	18	0,19	0,76	298,50
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,55	0,81
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,30
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,28	0,19
Hotels and Restaurants	22	1,72	1,67	-2,87
Inland Transport	23	0,32	0,34	6,97
Water Transport	24	-4,22	-4,22	-0,05
Air Transport	25	-3,41	-3,38	0,93
Other Supporting and Auxiliary Transport (...)	26	0,50	0,52	4,85
Post and Telecommunications	27	3,58	3,61	0,70
Financial Intermediation	28	2,49	2,51	0,83
Real Estate Activities	29	1,37	1,34	-2,01
Renting of M Eq and Other (...)	30	1,60	1,63	1,37
Public Admin and Defence; (...)	31	1,76	1,76	-0,19
Education	32	1,01	1,00	-0,64
Health and Social Work	33	1,35	1,38	1,95
Other Community, Social and Personal (...)	34	1,54	1,56	1,03

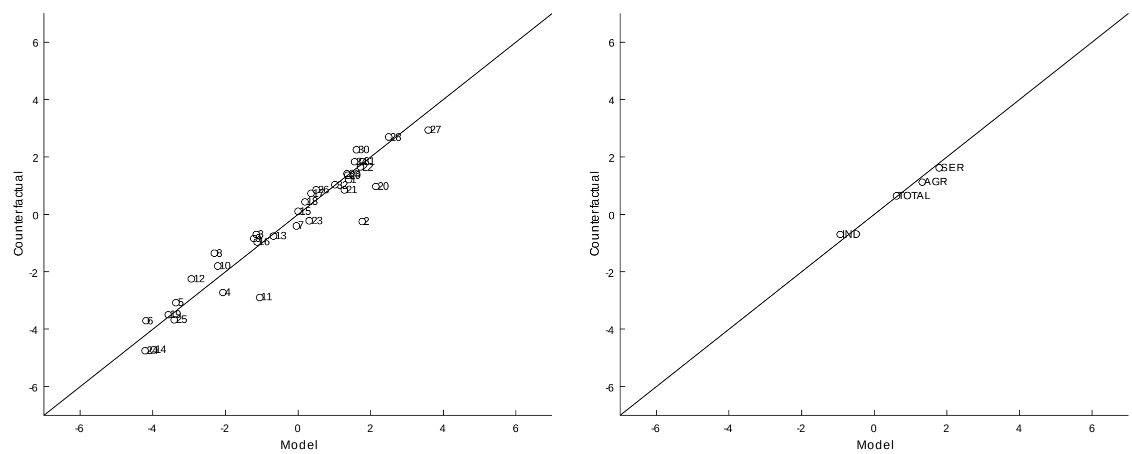
Table 2.10: Capital and labor intensities in Brazil's economic activities - C1.2

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,78	-2,92	0,19	0,22	12,29
Food, Beverages and Tobacco	3	0,87	0,97	11,05	0,13	0,03	-73,74
Textiles and Textile Products	4	0,69	0,68	-1,46	0,31	0,32	3,31
Leather, Leather and Footwear	5	0,75	0,62	-16,97	0,25	0,38	51,47
Wood and Products of Wood and Cork	6	0,68	0,62	-8,77	0,32	0,38	19,02
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,67	-8,01	0,27	0,33	22,05
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,88	-7,24	0,05	0,12	139,28
Chemicals and Chemical Products	9	0,82	0,82	-0,60	0,18	0,18	2,79
Rubber and Plastics	10	0,77	0,77	0,00	0,23	0,23	-0,01
Other Non-Metallic Mineral	11	0,72	0,69	-4,15	0,28	0,31	10,66
Basic Metals and Fabricated Metal	12	0,79	0,67	-14,85	0,21	0,33	56,27
Machinery, Nec	13	0,74	0,67	-9,28	0,26	0,33	26,36
Electrical and Optical Equipment	14	0,81	0,68	-16,20	0,19	0,32	68,21
Transport Equipment	15	0,82	0,82	0,79	0,18	0,18	-3,51
Manufacturing, Nec; Recycling	16	0,72	0,58	-18,96	0,28	0,42	49,04
Electricity, Gas and Water Supply	17	0,72	0,55	-23,83	0,28	0,45	61,15
Construction	18	0,65	0,46	-29,64	0,35	0,54	54,34
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.11: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.2

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,34	1,85	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,82	12,24	0,79	0,74	-6,16	0,21	0,26	23,02
Services	1,78	1,80	0,72	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,68	12,90	0,62	0,60	-3,62	0,38	0,40	5,91

Figure 14 depicts the results of counterfactual C1.3, and Tables 12, 13 and 14 report the statistics for this exercise.



(C1.3) 35 Activities (C1.3) 3-Sector and Total

Figure 2.14: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C1.3

When we replace the shares of all of Brazil's **domestic sectors** in the total cost of its **industry** by the corresponding cost shares of the US economy, productivity grows more in 19 activities, 11 of them belonging to industry and 8 to services. Once again, Electricity, Gas and Water Supply"(106,38%) and in "(#18) Construction"(130,51%) stand out from the other results of TFP growth in industry. In the service sector, we highlight the TFP growth improvements in "(#26) Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies"(70,51%) and in "(#30) Renting of M Eq and Other Business Activities"(see table 12). It is interesting to note from Table 11 that labor intensity is higher in counterfactual than in the model in almost all industrial activities.

The right hand side panel of Figure 14 and Table 14 show that although industry is the only sector to experience a higher result for TFP's growth in the counterfactual than in the model, its increase of more than 25% leads the productivity's growth results in total economy, which increases 7,13% more than in the model. Once again, labor share in industry is higher in the counterfactual than in the model (growing 31,21%), and, in total economy, increases from 38% to 41%.

Table 2.12: Annualized growth rates of TFP in Brazil's economic activities - C1.3

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,20	-14,02
Mining and Quarrying	2	1,76	-0,24	-86,06
Food, Beverages and Tobacco	3	-1,16	-0,70	39,79
Textiles and Textile Products	4	-2,06	-2,73	-32,41
Leather, Leather and Footwear	5	-3,36	-3,08	8,25
Wood and Products of Wood and Cork	6	-4,20	-3,72	11,38
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,39	-752,32
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-1,36	40,82
Chemicals and Chemical Products	9	-1,23	-0,85	30,81
Rubber and Plastics	10	-2,21	-1,80	18,68
Other Non-Metallic Mineral	11	-1,07	-2,89	-170,40
Basic Metals and Fabricated Metal	12	-2,93	-2,25	23,13
Machinery, Nec	13	-0,68	-0,75	-9,86
Electrical and Optical Equipment	14	-3,99	-4,72	-18,33
Transport Equipment	15	0,00	0,10	3355,91
Manufacturing, Nec; Recycling	16	-1,14	-0,96	16,03
Electricity, Gas and Water Supply	17	0,36	0,74	106,38
Construction	18	0,19	0,44	130,51
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,50	2,11
Wholesale Trade and Commission Trade (...)	20	2,14	0,96	-55,12
Retail Trade, Except of Motor Vehicles (...)	21	1,28	0,85	-33,30
Hotels and Restaurants	22	1,72	1,64	-4,58
Inland Transport	23	0,32	-0,23	-171,42
Water Transport	24	-4,22	-4,74	-12,46
Air Transport	25	-3,41	-3,68	-7,99
Other Supporting and Auxiliary Transport (...)	26	0,50	0,85	70,51
Post and Telecommunications	27	3,58	2,94	-17,86
Financial Intermediation	28	2,49	2,69	7,90
Real Estate Activities	29	1,37	1,34	-2,06
Renting of M Eq and Other (...)	30	1,60	2,24	39,67
Public Admin and Defence; (...)	31	1,76	1,84	4,76
Education	32	1,01	1,01	0,25
Health and Social Work	33	1,35	1,41	4,06
Other Community, Social and Personal (...)	34	1,54	1,83	18,67

Table 2.13: Capital and labor intensities in Brazil's economic activities - C1.3

Activity		Capital Intensity model	counterf	(%)	Labor Intensity model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,69	-14,19	0,19	0,31	59,70
Food, Beverages and Tobacco	3	0,87	0,82	-5,76	0,13	0,18	38,44
Textiles and Textile Products	4	0,69	0,70	1,20	0,31	0,30	-2,72
Leather, Leather and Footwear	5	0,75	0,62	-17,71	0,25	0,38	53,70
Wood and Products of Wood and Cork	6	0,68	0,72	4,88	0,32	0,28	-10,59
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,73	-1,08	0,27	0,27	2,99
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,77	-18,87	0,05	0,23	362,98
Chemicals and Chemical Products	9	0,82	0,81	-1,74	0,18	0,19	8,15
Rubber and Plastics	10	0,77	0,75	-3,33	0,23	0,25	11,29
Other Non-Metallic Mineral	11	0,72	0,72	0,31	0,28	0,28	-0,78
Basic Metals and Fabricated Metal	12	0,79	0,69	-12,84	0,21	0,31	48,65
Machinery, Nec	13	0,74	0,69	-6,98	0,26	0,31	19,82
Electrical and Optical Equipment	14	0,81	0,69	-14,00	0,19	0,31	58,94
Transport Equipment	15	0,82	0,77	-5,70	0,18	0,23	25,31
Manufacturing, Nec; Recycling	16	0,72	0,65	-10,31	0,28	0,35	26,67
Electricity, Gas and Water Supply	17	0,72	0,64	-10,95	0,28	0,36	28,10
Construction	18	0,65	0,55	-14,27	0,35	0,45	26,17
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.14: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.3

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,12	-14,67	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,70	25,36	0,79	0,72	-8,35	0,21	0,28	31,21
Services	1,78	1,62	-9,33	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,64	7,13	0,62	0,59	-4,89	0,38	0,41	8,00

In sum, these counterfactuals show that, depending on which cost shares we choose to replace, the impacts on sectoral and aggregate productivity are several and do not only take place in industry itself, but also throughout the economy, as expected. In this sense, the best results - in terms of enhancing TFP growth - seem to be achieved with the substitutions carried out by counterfactual C1.2, in that they were able to improve TFP in a higher number of activities and, as a result, to boost TFP growth rates in all three sectors and in total economy.

Finally, we redo these 3 exercises considering only the activities assigned to "manufacturing", instead of "industry", following Table A2's (from Appendix 1) correspondences. The results of these counterfactuals are depicted on Figure 16 and reported in Tables 19-27, presented in Appendix 2.

As one can verify, the outcomes are very similar to the ones described in this section. The most significant differences between each pairs of corresponding counterfactuals[32] can be observed in those activities assigned to only industry - according to the 3-sector classification - but not to manufacturing - following the 10-Sector Classification, which are: "(#2) Mining and Quarrying", '(#17) Electricity, Gas and Water Supply"and "(#18) Construction".

With respect to sectoral results, note first that, comparing the results from C1.4 (related to changes in manufacturing) with C1.1 (related to changes in industry), industry grows 3 times more in the former, which results in a 40% smaller decrease in productivity in total economy. In contrast, in counterfactual C1.2 (related to changes in industry), productivity in agriculture, industry and services grows more than in counterfactual C1.5 (related to changes in manufacturing), resulting in a 2 times higher productivity growth in total economy in the latter. Lastly, in counterfactual C1.3 (related to changes in industry), productivity in total economy grows 40% more than in counterfactual C1.6 (related to changes in manufacturing).

International trade, cost shares and TFPs (C2)

The second set of counterfactuals emphasize the relevance of a country's specific choice of international trade partners - reflected on its preferred allocation of imported inputs - for its sectoral and total economy's productivities.

For these alternative counterfactuals, we ask the previous section's question again, but we do not impose any restrictions: all cost shares of interest are replaced by USA's cost shares, including the ones reflecting intermediate uses of **imported** outputs.

We again provide an example using the WIOT and matrix A schematic outline. Suppose we aim to assess how TFP changes in country A if we replace this country's share of sector 3's input in the cost of sector 1's output by the corresponding cost shares of country B.

Table 15 replicates only the rows of Table 2 we need to analyze. In the proposed counterfactual exercise, we replace the cost share $a_{1A,3A}$ with $a_{1B,3A}$, $a_{1A,3B}$ with $a_{1B,3B}$ and $a_{1A,3C}$ with $a_{1B,3C}$. After the proper replacements, $a'_{1A,j} = a_{1B,j}$, $j = \{1A, 1B, 1C\}$.

[32] We compare the following pairs of counterfactuals: C1.1 with C1.4, C1.2 with C1.5 and C1.3 with C1.6.

Table 2.15: Modified A matrix - Counterfactual 2

country	sector	A 1	A 2	A 3	B 1	B 2	B 3	C 1	C 2	C 3
A	1	$a_{1A,1A}$	$a_{1A,2A}$	$a_{1B,3A}$	$a_{1A,1B}$	$a_{1A,2B}$	$a_{1B,3B}$	$a_{1A,1C}$	$a_{1A,2C}$	$a_{1B,3C}$
A	2	.	.	.	.	.	.	.	.	.
A	3	.	.	.	.	.	.	.	.	.
B	1	$a_{1B,1A}$	$a_{1B,2A}$	$a_{1B,3A}$	$a_{1B,1B}$	$a_{1B,2B}$	$a_{1B,3B}$	$a_{1B,1C}$	$a_{1B,2C}$	$a_{1B,3C}$
B	2	.	.	.	.	.	.	.	.	.
B	3	.	.	.	.	.	.	.	.	.
C	1	.	.	.	.	.	.	.	.	.
C	2	.	.	.	.	.	.	.	.	.
C	3	.	.	.	.	.	.	.	.	.

For the reasons previously stated, we have to modify the values of the intermediate domestic inputs in a specific way, to force the cost shares to mach our hypothesis.

Rearranging (2.22), we obtain the proper modified values of $X_{1A,j}$ for $j = \{1A, 1B, 1C\}$ at each time t:

$$X'_{1A,j,t} = a'_{1A,j} \times TC^*_{1A,t} \tag{2.25}$$

$$= a_{1B,j} \times TC^*_{1A,t} \tag{2.26}$$

Table 2.16: Modified WIOT - Counterfactual 2

country		A	A	A	B	B	B	C	C	C	TIC_i	L_i	TC_i
	sector	1	2	3	1	2	3	1	2	3			
A	1	$X_{1A,1A}$	$X_{1A,2A}$	$\mathbf{X}'_{1A,3A}$	$X_{1A,1B}$	$X_{1A,2B}$	$\mathbf{X}'_{1A,3B}$	$X_{1A,1C}$	$X_{1A,2C}$	$\mathbf{X}'_{1A,3C}$	$\sum_j \mathbf{X}_{1A,j}$	$\mathbf{L}_{1A}$	TC_{1A}
A	2	.	.	$X_{2A,3A}$	.	.	$X_{2A,3B}$	.	.	$X_{2A,3C}$	.	.	.
A	3	.	.	$X_{3A,3A}$	.	.	$X_{3A,3B}$	.	.	$X_{3A,3C}$	.	.	.
B	1	.	.	$X_{1B,3A}$	.	.	$X_{1B,3B}$	.	.	$X_{1B,3C}$	.	.	.
B	2	.	.	$X_{2B,3A}$	.	.	$X_{2B,3B}$	.	.	$X_{2B,3C}$	.	.	.
B	3	.	.	$X_{3B,3A}$	.	.	$X_{3B,3B}$	.	.	$X_{3B,3C}$	.	.	.
C	1	.	.	$X_{1C,3A}$	.	.	$X_{1C,3B}$	.	.	$X_{1C,3C}$	.	.	.
C	2	.	.	$X_{2C,3A}$	.	.	$X_{2C,3B}$	.	.	$X_{2C,3C}$	.	.	.
C	3	.	.	$X_{3C,3A}$	.	.	$X_{3C,3B}$	.	.	$X_{3C,3C}$	.	.	.
$\sum_i X_{i,j}$		.	.	$\sum_i \mathbf{X}_{i,3A}$	.	.	$\sum_i \mathbf{X}_{i,3B}$	.	.	$\sum_i \mathbf{X}_{i,3C}$			
C_j		.	.	C_{3A}	.	.	C_{3B}	.	.	C_{3C}			
Y_j		.	.	$\mathbf{Y}_{3A}$	.	.	$\mathbf{Y}_{3B}$	.	.	$\mathbf{Y}_{3C}$			

This time, the new WIOTs, for all time t, will differ from the original tables by several entries: the values of $\mathbf{X}'_{1A,j}$, $j = \{1A, 1B, 1C\}$ and, thereafter, the values of $\sum_i \mathbf{X}_{i,j}$ and $\mathbf{Y}_j$, $j = \{1A, 1B, 1C\}$, $TIC_{1A} = \sum_j \mathbf{X}_{1A,j}$ and $\mathbf{L}_{1A}$. The consequences for our equilibrium quantities and the products of these alternative counterfactuals are analogous to the ones we derive in the previous section.

The three counterfactual exercises we perform in this section aim to answer the following questions:[33]

(C2.1)What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of **services** in the total cost of its **industry** by the corresponding cost shares of the US economy?

(C2.2) What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of **industry** in the total cost of its **industry** by the corresponding cost shares of the US economy?

(C2.3) What happens to Brazil's (sectoral and aggregate) total factor productivity's growth if we replace the shares of **all sectors** in the total cost of its **industry** by the corresponding cost shares of the US economy?

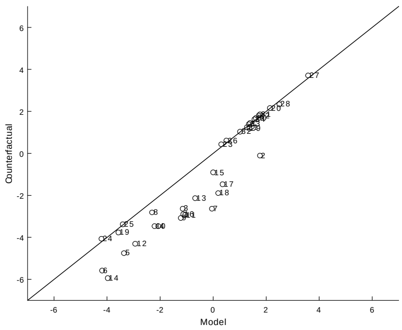
Results When we do not impose the restriction for the replacement of the cost shares to only affect those associated with intermediate uses of **domestic** output, the outcomes are very different from the ones we report in the previous section.

If the cost shares linked to intermediate uses of **imported** outputs are also subject to these substitutions, we are indirectly imposing to a country (e.g. to Brazil) the international structure of another given economy (e.g. of the USA) for the former's consuption of intermediate outputs.

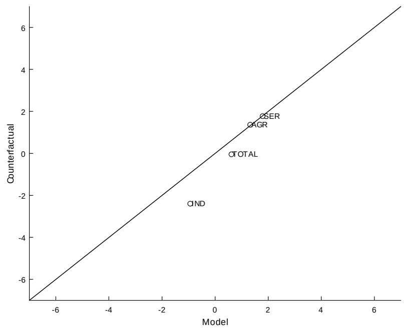
Moreover, when we replace $a_{1A,3A}$ with $a_{1B,3A}$, we are imposing country A's share of its domestic sector 3 in total costs of sector 1 to be of the same magnitude of country B's share of imports from country's A sector 3 in total costs of country's B sector 1. However, the former cost shares tend to be much higher than the latter, reflecting a preference for - in terms of higher shares of - domestic inputs in the costs of final outputs, relatively to imported inputs.

Figure 15 shows the results for these 3 counterfactuals. Their summary statistics are reported in Tables 28-36 in Appendix 2.

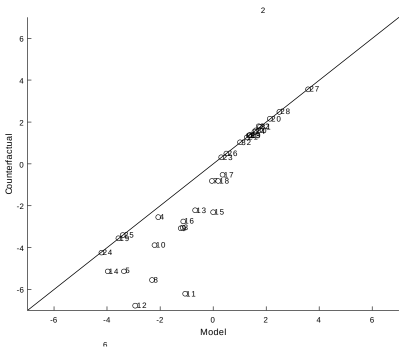
[33] In Appendix 2, we redo these 3 counterfactuals only for the activities assigned to "manufacturing", instead of "industry", following Table's A2 classification. As one can verify, the results are very much alike.



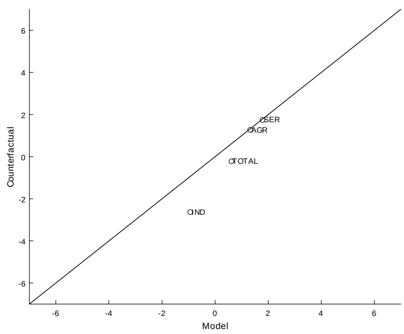
(C2.1) 35 Activities



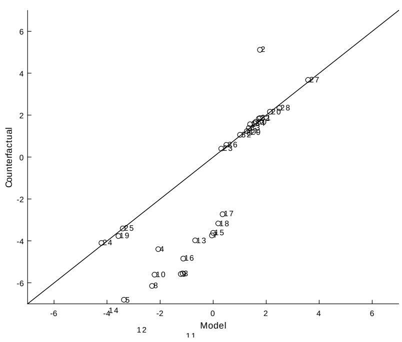
(C2.1) 3 Sector and Total



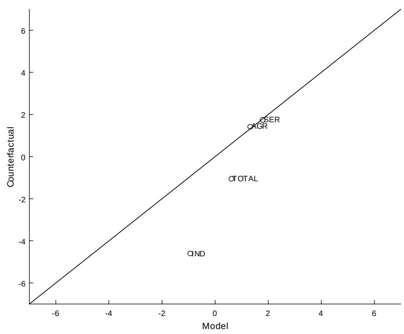
(C2.2) 35 Activities



(C2.1) 3 Sector and Total



(C2.3) 35 Activities



(C2.3) 3 Sector and Total

Figure 2.15: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C2

We begin by stressing that TFP growth in industry, services and total economy decrease in all 3 exercises. The higher drops ocurr in counterfactual C2.3, which replaces the shares of **all sectors** in the total cost of Brazil's **industry** by the corresponding cost shares of the US economy. TFP growth in industry falls 392,48%, in services 2,63% and in total economy 276,28%, relatively to the model.

It is also interesting to note that, in this particular exercise, of the activities that experienced higher productivity growth, none is assigned to the industrial sector. However, TFP grows more

in "(#1) Agriculture, Hunting, Forestry and Fishing", "(#2) Mining and Quarrying"and in 10 of the 16 service sector's activities.

In counterfactual C2.2 (that replaces the shares of **industry** in the total cost of Brazil's **industry** by the corresponding cost shares of the US economy), TFP grows less than in the model for all three sectors and total economy, as TFP growth in agriculture also decreases 4,46%. Of the 34 activities covered, 26 experienced productivity growth lower than in the model. Also, in 7 of the remaining 8 activities, the growth rates were the same in both scenarios. Only in "(#2) Mining and Quarrying"TFP growth rates are more than 4 times higher in the counterfactual than in the model.

TFP growth rate in Agriculture also increases in counterfactual C2.1 relatively to the model, but only by 2,25%. Industry experiences a decrease of 156,28% in its productivity growth and a decrease in labor intensity of 7,79%. However, in the other 2 counterfactuals, labor intensity on industry increases (13,81% in C2.2 and 20,88% in C2.3).

Similarly to what we performed in the previous section, we also redo these 3 counterfactuals considering only the activities assigned to "manufacturing", instead of "industry". The results of these exercises are reported on Figure 17 and in Tables 37-45, all presented in Appendix 2. As expected, these new counterfactual's outcomes are again very similar to the ones we have just described, except for the activities assigned only to industry, but not to manufacturing: "(#2) Mining and Quarrying", '(#17) Electricity, Gas and Water Supply"and "(#18) Construction".

These results indicate that the optimum choice of international suppliers, as well as the trade-off between domestic and imported inputs, as prescript by the model, are consistent with a more flourishing productivity scenario. In other words, the changes in the parameters of the productivity function (i.e. in a_{ij} and b_i for a given i and for some j), as prescripted by these counterfactuals, are followed by a equilibrium such that optimum choices for the control variables reveal scenarios of lower productivity growth.

On the other hand, in the first set of counterfactuals, by replacing a country's uses of domestic intermediate outputs with another's - and so forcing the cost shares to match with the ones we specified - we are in fact substituting a given country's domestic sector's intensity in the use of its inputs with one from another country. In other words, we are replacing the domestic arrangement of a country's cost shares related to a given sector with one that was adopted by another country and that, by some previous evaluation, could be considered productivity enhancing. This other sort of shift in the model's parameters induces the reallocation of productive factors throughout the economy and, depending on whether the evaluation confirms to be accurate or not, is capable of enhancing growth rates of TFP, which can be higher in a wide range of activities and, therefore, in the aggregate outcomes.

2.5 Conclusions

In this paper, we evaluate the quantitative importance of sectoral cost shares in explaining sectoral and aggregate productivity growth. Following the alternative analytical setup provided by Ferreira et al. (2016) for estimating sectoral total factor productivities (TFP), we perform a comparative analysis concerning sectoral and country-level TFP growth rates in the USA and in Brazil and conduct two sets of counterfactual exercises.

We use data from the World Input-Output Database (WIOD) - which includes the World Input-Output Tables (WIOTs) and the Socio Economic Accounts (SEA) - for assessing patterns of TFP growth rates and performing the counterfactual exercises. This is is the same database that Ferreira et al (2016) adopted for constructing their sectoral total factor productivity series. The WIOD is the most up-to-date and comprehensive sectoral cross-country database, which enables a wide range of sectoral studies, as it provides data for 35 economic activities and 40 countries, from 1995 to 2009.

Some stylized facts using the series constructed by Ferreira et al. (2016) are documented before we proceed to our quantitative analysis. For instance, most of the aggregate TFP growth can be assigned to technological improvements in the service sector, for a considerably large number of countries. That is, not only productivity in services was higher than in industry for most of the countries, but it also exhibited higher growth rates over the years.

We then present an in-depth comparative analysis related to patterns of sectoral and aggregate TFP's growth rates in Brazil and in the USA from 1996 to 2009. We show that total factor productivity has increased in both countries. Concerning sectoral productivities, we find that since TFP in agriculture is positively related with total economy's productivity in Brazil, but there is a negative relation between the two corresponding series for the USA, it is likely that only in Brazil this sector has produced a positive effect over total economy's productivity.

Moreover, contrary to the common sense, productivity in industry has promoted an adverse effect over aggregate productivity in both countries. Lastly, it can be observed a marked productivity boom in the service sector in Brazil and in the USA. Both series are positively and highly correlated with the corresponding aggregate productivity index in total economies (the correlation coefficients are, respectively, 0,94 and 0,89). Therefore, we argue that productivity growth in the service sector was the main driving force for these aggregate productivity outcomes.

The main purpose of the counterfactual exercises we conduct in this paper is to assess to what extent changes on the cost shares associated with intermediate uses of outputs affect sectoral and aggregate total factor productivity growth. We perform 6 counterfactuals, 3 on each set of analysis, but first we present a 3x3 example - referring to an economy environment populated only by 3 countries and 3 sectors - which we believe may help elucidating the strategy we used for constructing our hypothetical scenarios.

In our first and main set of counterfactual exercises, we ask the following question: What happens to Brazil's (sectoral and aggregate) total factor productivity growth if we replace the shares of its intermediate uses of **domestic** outputs in the total cost of its **industry** by the corresponding cost shares of the US economy? We then narrow this investigation through different directions. First, we restrict the change in the intermediate uses of domestic outputs to affect only a specific sector at a time. Second, we redo the exercises considering only the cost shares in activities assigned to manufacturing, following the classification of the GGDC 10-Sector Database.

We find that, depending on which cost shares we choose to replace, the impacts on sectoral and aggregate productivity vary and not only in industry itself, but also throughout the economy. In this sense, the best results - in terms of enhancing TFP growth - seem to be achieved when we replace Brazil's shares of its **domestic industry** in the total cost of its **industry** by the corresponding cost shares of the US economy, in that they are able to improve TFP in a higher number of activities and, as a result, to boost TFP growth rates in all three sectors and in total economy.

In other words, by replacing a country's uses of domestic intermediate outputs with another's - and so forcing the cost shares to match with the ones we specified - we are in fact substituting a given country's domestic sector's intensity in the use of its inputs with one from another country. This shift in the model's parameters induces sectoral reallocation of productive factors and is capable of boost TFP growth rates, which can be higher in a wide range of activities and, therefore, in the aggregate outcomes.

We redo these 3 exercises considering only the activities assigned to "manufacturing", instead of "industry", and show that significant differences between each pairs of corresponding counterfactuals can only be observed in those activities assigned to industry but not to manufacturing.

The second set of counterfactuals emphasize the relevance of a country's specific choice of international trade partners - reflected on its preferred allocation of imported inputs - for its sectoral and total economy's productivities. For these alternative exercises, we also ask the

previous questions, but we do not impose any restrictions: all cost shares of interest are replaced by the US economy's cost shares, including the ones reflecting intermediate uses of **imported** outputs. We conclude that the optimum choice of international suppliers, as well as the trade-off between domestic and imported inputs, as prescript by our model, are consistent with a more flourishing productivity scenario. In other words, the changes in the parameters of the productivity function, as prescripted by these counterfactuals, are followed by a equilibrium such that optimum allocation choices reveal scenarios of lower productivity growth.

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Appendix 1

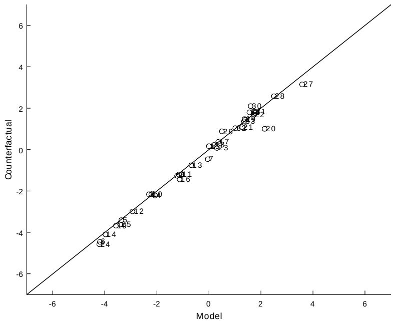
Table 2.17: ISIC 3.0 vs. 3-Sector Correspondence

	WIOD-ISIC3.0		3-Sector
1	Agriculture, Hunting, Forestry and Fishing	1	Agriculture
2	Mining and Quarrying	2	Industry
3	Food, Beverages and Tobacco	2	Industry
4	Textiles and Textile Products	2	Industry
5	Leather, Leather and Footwear	2	Industry
6	Wood and Products of Wood and Cork	2	Industry
7	Pulp, Paper, Paper , Printing and Publishing	2	Industry
8	Coke, Refined Petroleum and Nuclear Fuel	2	Industry
9	Chemicals and Chemical Products	2	Industry
10	Rubber and Plastics	2	Industry
11	Other Non-Metallic Mineral	2	Industry
12	Basic Metals and Fabricated Metal	2	Industry
13	Machinery, Nec	2	Industry
14	Electrical and Optical Equipment	2	Industry
15	Transport Equipment	2	Industry
16	Manufacturing, Nec; Recycling	2	Industry
17	Electricity, Gas and Water Supply	2	Industry
18	Construction	2	Industry
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	3	Services
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	3	Services
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	3	Services
22	Hotels and Restaurants	3	Services
23	Inland Transport	3	Services
24	Water Transport	3	Services
25	Air Transport	3	Services
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	3	Services
27	Post and Telecommunications	3	Services
28	Financial Intermediation	3	Services
29	Real Estate Activities	3	Services
30	Renting of M Eq and Other Business Activities	3	Services
31	Public Admin and Defence; Compulsory Social Security	3	Services
32	Education	3	Services
33	Health and Social Work	3	Services
34	Other Community, Social and Personal Services	3	Services
35	Private Households with Employed Persons	3	Services

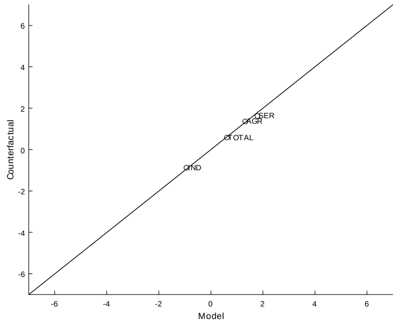
Table 2.18: ISIC 3.0 vs. 10-Sector Correspondence

	WIOD - ISIC 3.0		10-Sector
1	Agriculture, Hunting, Forestry and Fishing	1	Agriculture, Forestry, and Fishing
2	Mining and Quarrying	2	Mining and Quarrying
3	Food, Beverages and Tobacco	3	Manufacturing
4	Textiles and Textile Products	3	Manufacturing
5	Leather, Leather and Footwear	3	Manufacturing
6	Wood and Products of Wood and Cork	3	Manufacturing
7	Pulp, Paper, Paper , Printing and Publishing	3	Manufacturing
8	Coke, Refined Petroleum and Nuclear Fuel	3	Manufacturing
9	Chemicals and Chemical Products	3	Manufacturing
10	Rubber and Plastics	3	Manufacturing
11	Other Non-Metallic Mineral	3	Manufacturing
12	Basic Metals and Fabricated Metal	3	Manufacturing
13	Machinery, Nec	3	Manufacturing
14	Electrical and Optical Equipment	3	Manufacturing
15	Transport Equipment	3	Manufacturing
16	Manufacturing, Nec; Recycling	3	Manufacturing
17	Electricity, Gas and Water Supply	4	Public Utilities
18	Construction	5	Construction
19	Sale, Maintenance and Repair of Motor (...)	6	Wholesale and Retail Trade, Hotels and Restaurants
20	Wholesale Trade and Commission Trade (...)	6	Wholesale and Retail Trade, Hotels and Restaurants
21	Retail Trade, Except of Motor Vehicles (...)	6	Wholesale and Retail Trade, Hotels and Restaurants
22	Hotels and Restaurants	6	Wholesale and Retail Trade, Hotels and Restaurants
23	Inland Transport	7	Transport, Storage, and Communication
24	Water Transport	7	Transport, Storage, and Communication
25	Air Transport	7	Transport, Storage, and Communication
26	Other Supporting and Auxiliary Transport (...)	7	Transport, Storage, and Communication
27	Post and Telecommunications	7	Transport, Storage, and Communication
28	Financial Intermediation	8	Finance, Insurance, and Real Estate (b)
29	Real Estate Activities	8	Finance, Insurance, and Real Estate (b)
30	Renting of M Eq and Other Business (...)	8	Finance, Insurance, and Real Estate (b)
31	Public Admin and Defence (...)	10	Government Services
32	Education	10	Government Services
33	Health and Social Work	10	Government Services
34	Other Community, Social and Personal (...)	9	Community, Social and Personal Services
35	Private Households with Employed Persons	9	Community, Social and Personal Services

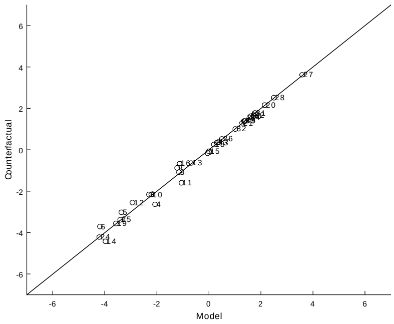
Appendix 2



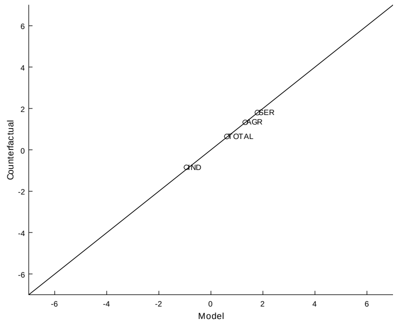
(C1.4) 35 Activities



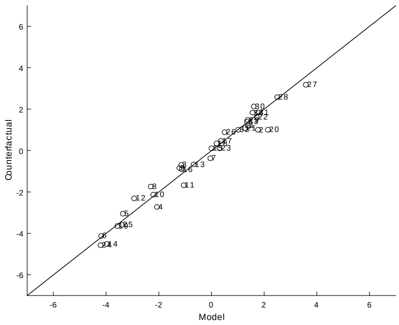
(C1.4) 3 Sector and Total



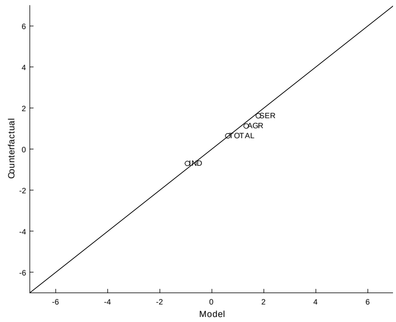
(C1.5) 35 Activities



(C1.5) 3 Sector and Total



(C1.6) 35 Activities



(C1.6) 3 Sector and Total

Figure 2.16: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C1

Table 2.19: Annualized growth rates of TFP in Brazil's economic activities - C1.4

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,43	2,54
Mining and Quarrying	2	1,76	1,77	1,13
Food, Beverages and Tobacco	3	-1,16	-1,21	-4,09
Textiles and Textile Products	4	-2,06	-2,21	-7,18
Leather, Leather and Footwear	5	-3,36	-3,41	-1,72
Wood and Products of Wood and Cork	6	-4,20	-4,44	-5,81
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,46	-893,02
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,15	6,60
Chemicals and Chemical Products	9	-1,23	-1,25	-1,99
Rubber and Plastics	10	-2,21	-2,17	1,78
Other Non-Metallic Mineral	11	-1,07	-1,21	-12,82
Basic Metals and Fabricated Metal	12	-2,93	-2,99	-2,09
Machinery, Nec	13	-0,68	-0,77	-12,43
Electrical and Optical Equipment	14	-3,99	-4,10	-2,99
Transport Equipment	15	0,00	0,16	5357,21
Manufacturing, Nec; Recycling	16	-1,14	-1,43	-25,39
Electricity, Gas and Water Supply	17	0,36	0,37	2,93
Construction	18	0,19	0,22	17,12
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,68	-2,97
Wholesale Trade and Commission Trade (...)	20	2,14	1,00	-53,31
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,08	-15,66
Hotels and Restaurants	22	1,72	1,69	-2,08
Inland Transport	23	0,32	0,08	-73,20
Water Transport	24	-4,22	-4,58	-8,53
Air Transport	25	-3,41	-3,61	-6,09
Other Supporting and Auxiliary Transport (...)	26	0,50	0,86	73,78
Post and Telecommunications	27	3,58	3,15	-12,13
Financial Intermediation	28	2,49	2,57	3,23
Real Estate Activities	29	1,37	1,46	6,56
Renting of M Eq and Other (...)	30	1,60	2,09	30,61
Public Admin and Defence; (...)	31	1,76	1,84	4,40
Education	32	1,01	1,02	0,52
Health and Social Work	33	1,35	1,36	0,95
Other Community, Social and Personal (...)	34	1,54	1,80	16,59

Table 2.20: Capital and labor intensities in Brazil's economic activities - C1.4

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,87	0,46	0,13	0,13	-3,07
Textiles and Textile Products	4	0,69	0,72	4,09	0,31	0,28	-9,25
Leather, Leather and Footwear	5	0,75	0,75	-0,10	0,25	0,25	0,30
Wood and Products of Wood and Cork	6	0,68	0,75	10,02	0,32	0,25	-21,73
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,83	13,43	0,27	0,17	-36,98
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,90	-5,25	0,05	0,10	101,03
Chemicals and Chemical Products	9	0,82	0,82	-0,88	0,18	0,18	4,13
Rubber and Plastics	10	0,77	0,75	-3,03	0,23	0,25	10,26
Other Non-Metallic Mineral	11	0,72	0,76	5,16	0,28	0,24	-13,24
Basic Metals and Fabricated Metal	12	0,79	0,81	2,06	0,21	0,19	-7,82
Machinery, Nec	13	0,74	0,76	2,32	0,26	0,24	-6,58
Electrical and Optical Equipment	14	0,81	0,83	2,22	0,19	0,17	-9,33
Transport Equipment	15	0,82	0,76	-6,46	0,18	0,24	28,66
Manufacturing, Nec; Recycling	16	0,72	0,79	9,26	0,28	0,21	-23,95
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.21: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.4

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,35	3,03	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,89	5,45	0,79	0,79	0,38	0,21	0,21	-1,43
Services	1,78	1,62	-9,17	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,57	-5,50	0,62	0,62	0,23	0,38	0,38	-0,38

Table 2.22: Annualized growth rates of TFP in Brazil's economic activities - C1.5

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,40	0,38
Mining and Quarrying	2	1,76	1,77	0,77
Food, Beverages and Tobacco	3	-1,16	-1,10	5,84
Textiles and Textile Products	4	-2,06	-2,63	-27,68
Leather, Leather and Footwear	5	-3,36	-3,04	9,52
Wood and Products of Wood and Cork	6	-4,20	-3,72	11,33
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,16	-239,41
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,16	6,22
Chemicals and Chemical Products	9	-1,23	-0,87	28,93
Rubber and Plastics	10	-2,21	-2,17	1,78
Other Non-Metallic Mineral	11	-1,07	-1,60	-49,83
Basic Metals and Fabricated Metal	12	-2,93	-2,55	12,84
Machinery, Nec	13	-0,68	-0,63	7,83
Electrical and Optical Equipment	14	-3,99	-4,42	-10,86
Transport Equipment	15	0,00	-0,09	-2768,37
Manufacturing, Nec; Recycling	16	-1,14	-0,66	41,90
Electricity, Gas and Water Supply	17	0,36	0,37	4,91
Construction	18	0,19	0,26	37,84
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,57	0,12
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,34
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,28	0,49
Hotels and Restaurants	22	1,72	1,67	-2,76
Inland Transport	23	0,32	0,34	7,86
Water Transport	24	-4,22	-4,21	0,17
Air Transport	25	-3,41	-3,38	0,82
Other Supporting and Auxiliary Transport (...)	26	0,50	0,52	5,26
Post and Telecommunications	27	3,58	3,61	0,82
Financial Intermediation	28	2,49	2,51	0,79
Real Estate Activities	29	1,37	1,39	1,05
Renting of M Eq and Other (...)	30	1,60	1,63	1,54
Public Admin and Defence; (...)	31	1,76	1,76	0,00
Education	32	1,01	1,01	-0,08
Health and Social Work	33	1,35	1,39	2,60
Other Community, Social and Personal (...)	34	1,54	1,56	1,17

Table 2.23: Capital and labor intensities in Brazil's economic activities - C1.5

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,96	10,21	0,13	0,04	-68,11
Textiles and Textile Products	4	0,69	0,69	-0,69	0,31	0,31	1,56
Leather, Leather and Footwear	5	0,75	0,63	-16,51	0,25	0,37	50,07
Wood and Products of Wood and Cork	6	0,68	0,63	-8,50	0,32	0,37	18,44
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,68	-7,17	0,27	0,32	19,75
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,82	-13,55	0,05	0,18	260,69
Chemicals and Chemical Products	9	0,82	0,82	0,08	0,18	0,18	-0,38
Rubber and Plastics	10	0,77	0,77	0,07	0,23	0,23	-0,24
Other Non-Metallic Mineral	11	0,72	0,69	-4,23	0,28	0,31	10,85
Basic Metals and Fabricated Metal	12	0,79	0,74	-6,62	0,21	0,26	25,10
Machinery, Nec	13	0,74	0,68	-8,35	0,26	0,32	23,72
Electrical and Optical Equipment	14	0,81	0,68	-15,24	0,19	0,32	64,17
Transport Equipment	15	0,82	0,84	2,45	0,18	0,16	-10,89
Manufacturing, Nec; Recycling	16	0,72	0,59	-18,49	0,28	0,41	47,82
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.24: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.5

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,33	1,45	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,86	7,95	0,79	0,77	-1,78	0,21	0,23	6,66
Services	1,78	1,79	0,51	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,64	6,13	0,62	0,61	-1,07	0,38	0,39	1,75

Table 2.25: Annualized growth rates of TFP in Brazil's economic activities - C1.6

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,19	-14,59
Mining and Quarrying	2	1,76	0,99	-43,42
Food, Beverages and Tobacco	3	-1,16	-0,70	40,15
Textiles and Textile Products	4	-2,06	-2,73	-32,45
Leather, Leather and Footwear	5	-3,36	-3,06	8,75
Wood and Products of Wood and Cork	6	-4,20	-4,12	1,92
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,36	-692,84
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-1,74	24,31
Chemicals and Chemical Products	9	-1,23	-0,85	31,02
Rubber and Plastics	10	-2,21	-2,12	4,02
Other Non-Metallic Mineral	11	-1,07	-1,68	-57,46
Basic Metals and Fabricated Metal	12	-2,93	-2,30	21,60
Machinery, Nec	13	-0,68	-0,68	0,61
Electrical and Optical Equipment	14	-3,99	-4,51	-13,17
Transport Equipment	15	0,00	0,12	3905,65
Manufacturing, Nec; Recycling	16	-1,14	-0,92	19,47
Electricity, Gas and Water Supply	17	0,36	0,46	29,78
Construction	18	0,19	0,33	73,99
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,66	-2,32
Wholesale Trade and Commission Trade (...)	20	2,14	1,01	-52,99
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,08	-15,38
Hotels and Restaurants	22	1,72	1,62	-5,83
Inland Transport	23	0,32	0,11	-66,05
Water Transport	24	-4,22	-4,57	-8,30
Air Transport	25	-3,41	-3,58	-5,18
Other Supporting and Auxiliary Transport (...)	26	0,50	0,89	78,95
Post and Telecommunications	27	3,58	3,18	-11,28
Financial Intermediation	28	2,49	2,59	4,01
Real Estate Activities	29	1,37	1,47	7,14
Renting of M Eq and Other (...)	30	1,60	2,12	32,00
Public Admin and Defence; (...)	31	1,76	1,84	4,34
Education	32	1,01	1,01	0,21
Health and Social Work	33	1,35	1,40	3,47
Other Community, Social and Personal (...)	34	1,54	1,82	17,77

Table 2.26: Capital and labor intensities in Brazil's economic activities - C1.6

Activity		Capital Intensity model	counterf	(%)	Labor Intensity model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,82	-5,76	0,13	0,18	38,44
Textiles and Textile Products	4	0,69	0,70	1,20	0,31	0,30	-2,72
Leather, Leather and Footwear	5	0,75	0,62	-17,71	0,25	0,38	53,70
Wood and Products of Wood and Cork	6	0,68	0,72	4,88	0,32	0,28	-10,59
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,73	-1,08	0,27	0,27	2,99
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,77	-18,87	0,05	0,23	362,98
Chemicals and Chemical Products	9	0,82	0,81	-1,74	0,18	0,19	8,15
Rubber and Plastics	10	0,77	0,75	-3,33	0,23	0,25	11,29
Other Non-Metallic Mineral	11	0,72	0,72	0,31	0,28	0,28	-0,78
Basic Metals and Fabricated Metal	12	0,79	0,69	-12,84	0,21	0,31	48,65
Machinery, Nec	13	0,74	0,69	-6,98	0,26	0,31	19,82
Electrical and Optical Equipment	14	0,81	0,69	-14,00	0,19	0,31	58,94
Transport Equipment	15	0,82	0,77	-5,70	0,18	0,23	25,31
Manufacturing, Nec; Recycling	16	0,72	0,65	-10,31	0,28	0,35	26,67
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.27: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C1.6

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,12	-14,66	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-0,70	25,44	0,79	0,74	-5,97	0,21	0,26	22,31
Services	1,78	1,63	-8,55	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,63	5,01	0,62	0,60	-3,51	0,38	0,40	5,73

Table 2.28: Annualized growth rates of TFP in Brazil's economic activities - C2.1

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,43	2,65
Mining and Quarrying	2	1,76	-0,12	-106,58
Food, Beverages and Tobacco	3	-1,16	-2,62	-125,45
Textiles and Textile Products	4	-2,06	-3,47	-68,35
Leather, Leather and Footwear	5	-3,36	-4,74	-41,16
Wood and Products of Wood and Cork	6	-4,20	-5,60	-33,30
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-2,64	-5641,27
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,82	-22,62
Chemicals and Chemical Products	9	-1,23	-3,08	-150,89
Rubber and Plastics	10	-2,21	-3,47	-56,60
Other Non-Metallic Mineral	11	-1,07	-2,95	-175,74
Basic Metals and Fabricated Metal	12	-2,93	-4,30	-46,86
Machinery, Nec	13	-0,68	-2,14	-214,46
Electrical and Optical Equipment	14	-3,99	-5,95	-49,28
Transport Equipment	15	0,00	-0,92	-29774,02
Manufacturing, Nec; Recycling	16	-1,14	-2,91	-154,97
Electricity, Gas and Water Supply	17	0,36	-1,46	-510,50
Construction	18	0,19	-1,88	-1089,84
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,76	-5,06
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,06
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,23	-3,23
Hotels and Restaurants	22	1,72	1,79	4,22
Inland Transport	23	0,32	0,42	32,99
Water Transport	24	-4,22	-4,07	3,41
Air Transport	25	-3,41	-3,39	0,52
Other Supporting and Auxiliary Transport (...)	26	0,50	0,60	20,84
Post and Telecommunications	27	3,58	3,70	3,27
Financial Intermediation	28	2,49	2,34	-5,88
Real Estate Activities	29	1,37	1,19	-13,43
Renting of M Eq and Other (...)	30	1,60	1,70	5,74
Public Admin and Defence; (...)	31	1,76	1,86	5,76
Education	32	1,01	1,04	2,69
Health and Social Work	33	1,35	1,39	3,25
Other Community, Social and Personal (...)	34	1,54	1,62	4,94

Table 2.29: Capital and labor intensities in Brazil's economic activities - C2.1

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,71	-12,49	0,19	0,29	52,55
Food, Beverages and Tobacco	3	0,87	0,88	0,67	0,13	0,12	-4,46
Textiles and Textile Products	4	0,69	0,72	4,40	0,31	0,28	-9,96
Leather, Leather and Footwear	5	0,75	0,75	0,35	0,25	0,25	-1,05
Wood and Products of Wood and Cork	6	0,68	0,75	10,15	0,32	0,25	-22,01
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,83	13,65	0,27	0,17	-37,57
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,90	-5,16	0,05	0,10	99,34
Chemicals and Chemical Products	9	0,82	0,82	-0,63	0,18	0,18	2,97
Rubber and Plastics	10	0,77	0,75	-2,96	0,23	0,25	10,01
Other Non-Metallic Mineral	11	0,72	0,76	5,03	0,28	0,24	-12,91
Basic Metals and Fabricated Metal	12	0,79	0,81	2,10	0,21	0,19	-7,96
Machinery, Nec	13	0,74	0,76	2,53	0,26	0,24	-7,19
Electrical and Optical Equipment	14	0,81	0,83	2,40	0,19	0,17	-10,12
Transport Equipment	15	0,82	0,76	-6,64	0,18	0,24	29,48
Manufacturing, Nec; Recycling	16	0,72	0,79	9,66	0,28	0,21	-24,97
Electricity, Gas and Water Supply	17	0,72	0,81	12,88	0,28	0,19	-33,06
Construction	18	0,65	0,75	15,50	0,35	0,25	-28,42
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.30: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.1

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,34	2,25	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-2,40	-156,28	0,79	0,81	2,09	0,21	0,19	-7,79
Services	1,78	1,77	-0,98	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	-0,04	-107,08	0,62	0,63	1,21	0,38	0,37	-1,98

Table 2.31: Annualized growth rates of TFP in Brazil's economic activities - C2.2

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,38	-1,01
Mining and Quarrying	2	1,76	7,32	317,34
Food, Beverages and Tobacco	3	-1,16	-3,05	-162,26
Textiles and Textile Products	4	-2,06	-2,56	-23,95
Leather, Leather and Footwear	5	-3,36	-5,12	-52,62
Wood and Products of Wood and Cork	6	-4,20	-8,65	-106,04
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,82	-1680,66
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-5,56	-141,79
Chemicals and Chemical Products	9	-1,23	-3,09	-151,72
Rubber and Plastics	10	-2,21	-3,89	-75,84
Other Non-Metallic Mineral	11	-1,07	-6,22	-482,10
Basic Metals and Fabricated Metal	12	-2,93	-6,77	-131,05
Machinery, Nec	13	-0,68	-2,23	-227,10
Electrical and Optical Equipment	14	-3,99	-5,15	-29,21
Transport Equipment	15	0,00	-2,31	-74416,28
Manufacturing, Nec; Recycling	16	-1,14	-2,75	-141,37
Electricity, Gas and Water Supply	17	0,36	-0,53	-248,11
Construction	18	0,19	-0,83	-537,18
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,57	0,04
Wholesale Trade and Commission Trade (...)	20	2,14	2,14	0,01
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,28	0,19
Hotels and Restaurants	22	1,72	1,79	3,90
Inland Transport	23	0,32	0,30	-3,74
Water Transport	24	-4,22	-4,23	-0,43
Air Transport	25	-3,41	-3,41	-0,22
Other Supporting and Auxiliary Transport (...)	26	0,50	0,48	-2,89
Post and Telecommunications	27	3,58	3,57	-0,35
Financial Intermediation	28	2,49	2,49	0,04
Real Estate Activities	29	1,37	1,34	-1,96
Renting of M Eq and Other (...)	30	1,60	1,59	-0,63
Public Admin and Defence; (...)	31	1,76	1,77	0,47
Education	32	1,01	1,02	0,60
Health and Social Work	33	1,35	1,35	-0,17
Other Community, Social and Personal (...)	34	1,54	1,53	-0,64

Table 2.32: Capital and labor intensities in Brazil's economic activities - C2.2

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,79	-2,42	0,19	0,21	10,19
Food, Beverages and Tobacco	3	0,87	0,98	12,16	0,13	0,02	-81,14
Textiles and Textile Products	4	0,69	0,70	0,37	0,31	0,30	-0,84
Leather, Leather and Footwear	5	0,75	0,70	-7,53	0,25	0,30	22,84
Wood and Products of Wood and Cork	6	0,68	0,66	-3,74	0,32	0,34	8,11
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,68	-7,46	0,27	0,32	20,53
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	1,03	8,15	0,05	-0,03	
Chemicals and Chemical Products	9	0,82	0,82	-0,66	0,18	0,18	3,07
Rubber and Plastics	10	0,77	0,77	-0,34	0,23	0,23	1,16
Other Non-Metallic Mineral	11	0,72	0,69	-3,92	0,28	0,31	10,06
Basic Metals and Fabricated Metal	12	0,79	0,69	-12,25	0,21	0,31	46,45
Machinery, Nec	13	0,74	0,70	-5,59	0,26	0,30	15,88
Electrical and Optical Equipment	14	0,81	0,64	-21,24	0,19	0,36	89,42
Transport Equipment	15	0,82	0,84	3,03	0,18	0,16	-13,46
Manufacturing, Nec; Recycling	16	0,72	0,60	-16,17	0,28	0,40	41,83
Electricity, Gas and Water Supply	17	0,72	0,58	-19,11	0,28	0,42	49,05
Construction	18	0,65	0,46	-28,79	0,35	0,54	52,78
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.33: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.2

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,26	-4,46	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-2,64	-182,14	0,79	0,76	-3,70	0,21	0,24	13,81
Services	1,78	1,75	-1,57	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	-0,22	-137,38	0,62	0,61	-2,17	0,38	0,39	3,54

Table 2.34: Annualized growth rates of TFP in Brazil's economic activities - C2.3

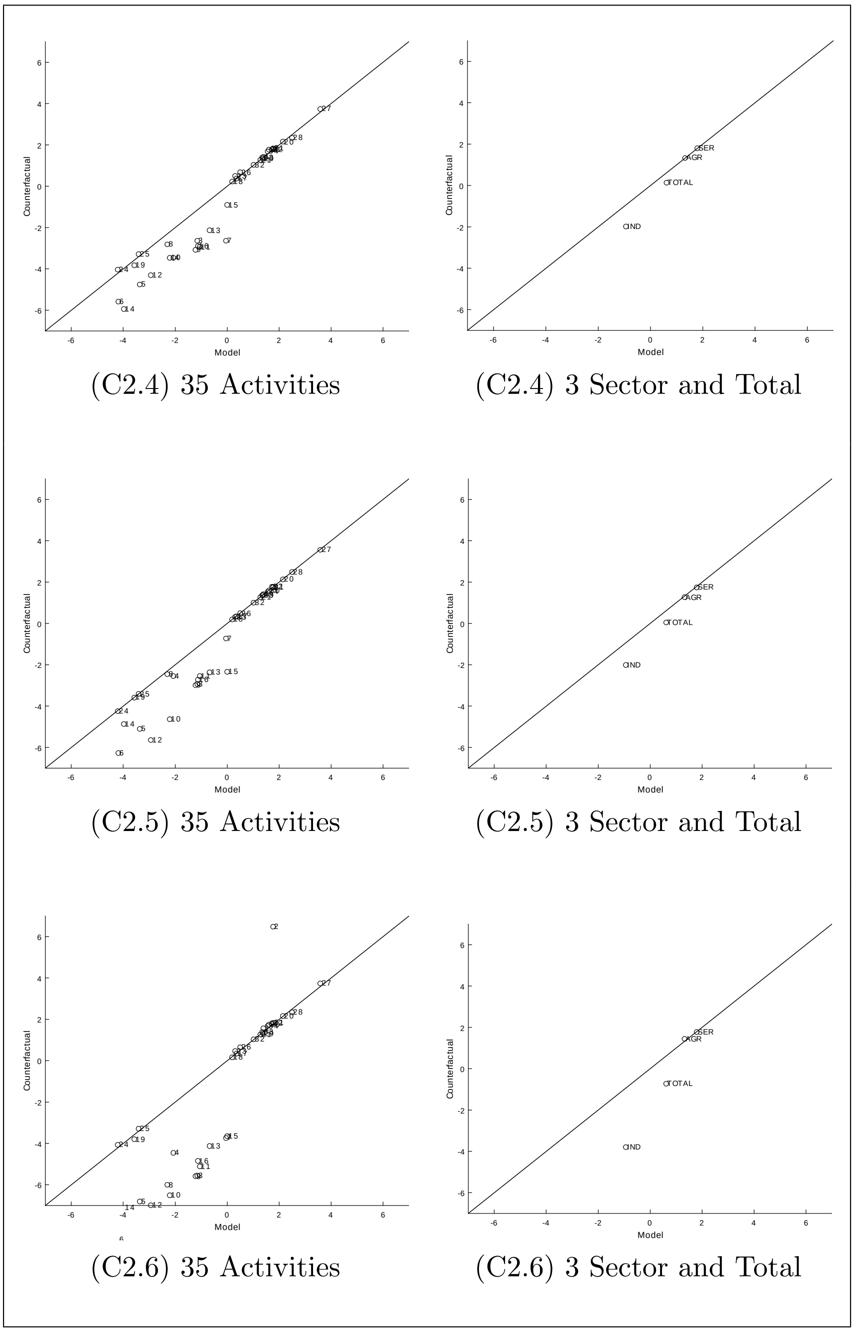
		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,56	12,04
Mining and Quarrying	2	1,76	5,12	191,49
Food, Beverages and Tobacco	3	-1,16	-5,55	-377,25
Textiles and Textile Products	4	-2,06	-4,40	-113,24
Leather, Leather and Footwear	5	-3,36	-6,82	-103,17
Wood and Products of Wood and Cork	6	-4,20	-10,57	-151,80
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-3,73	-8025,17
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-6,15	-167,48
Chemicals and Chemical Products	9	-1,23	-5,59	-355,55
Rubber and Plastics	10	-2,21	-5,61	-153,30
Other Non-Metallic Mineral	11	-1,07	-8,54	-698,86
Basic Metals and Fabricated Metal	12	-2,93	-8,27	-182,10
Machinery, Nec	13	-0,68	-3,99	-485,34
Electrical and Optical Equipment	14	-3,99	-7,33	-83,90
Transport Equipment	15	0,00	-3,61	-116084,58
Manufacturing, Nec; Recycling	16	-1,14	-4,83	-323,40
Electricity, Gas and Water Supply	17	0,36	-2,71	-859,97
Construction	18	0,19	-3,19	-1773,49
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,75	-5,01
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,07
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,24	-3,04
Hotels and Restaurants	22	1,72	1,84	6,87
Inland Transport	23	0,32	0,41	29,08
Water Transport	24	-4,22	-4,09	2,97
Air Transport	25	-3,41	-3,40	0,30
Other Supporting and Auxiliary Transport (...)	26	0,50	0,59	17,83
Post and Telecommunications	27	3,58	3,68	2,90
Financial Intermediation	28	2,49	2,34	-5,85
Real Estate Activities	29	1,37	1,16	-15,39
Renting of M Eq and Other (...)	30	1,60	1,69	5,07
Public Admin and Defence; (...)	31	1,76	1,87	6,20
Education	32	1,01	1,04	3,23
Health and Social Work	33	1,35	1,39	3,02
Other Community, Social and Personal (...)	34	1,54	1,61	4,27

Table 2.35: Capital and labor intensities in Brazil's economic activities - C2.3

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,69	-14,96	0,19	0,31	62,92
Food, Beverages and Tobacco	3	0,87	0,84	-3,25	0,13	0,16	21,68
Textiles and Textile Products	4	0,69	0,72	3,46	0,31	0,28	-7,82
Leather, Leather and Footwear	5	0,75	0,69	-7,81	0,25	0,31	23,70
Wood and Products of Wood and Cork	6	0,68	0,75	9,72	0,32	0,25	-21,08
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,73	-0,68	0,27	0,27	1,88
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,92	-3,43	0,05	0,08	66,05
Chemicals and Chemical Products	9	0,82	0,81	-1,54	0,18	0,19	7,18
Rubber and Plastics	10	0,77	0,74	-3,58	0,23	0,26	12,11
Other Non-Metallic Mineral	11	0,72	0,72	0,39	0,28	0,28	-0,99
Basic Metals and Fabricated Metal	12	0,79	0,71	-10,21	0,21	0,29	38,69
Machinery, Nec	13	0,74	0,72	-3,08	0,26	0,28	8,74
Electrical and Optical Equipment	14	0,81	0,66	-18,85	0,19	0,34	79,37
Transport Equipment	15	0,82	0,79	-3,65	0,18	0,21	16,18
Manufacturing, Nec; Recycling	16	0,72	0,67	-7,13	0,28	0,33	18,45
Electricity, Gas and Water Supply	17	0,72	0,67	-6,26	0,28	0,33	16,07
Construction	18	0,65	0,56	-13,17	0,35	0,44	24,15
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.36: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.3

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,43	8,59	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-4,62	-392,48	0,79	0,74	-5,59	0,21	0,26	20,88
Services	1,78	1,74	-2,63	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	-1,06	-276,28	0,62	0,60	-3,27	0,38	0,40	5,34



(C2.4) 35 Activities (C2.4) 3 Sector and Total

(C2.5) 35 Activities (C2.5) 3 Sector and Total

(C2.6) 35 Activities (C2.6) 3 Sector and Total

Figure 2.17: Annualized growth rates of TFP in Brazil's 35 activities/3 sectors/total economy in the model and in the counterfactual C2

Table 2.37: Annualized growth rates of TFP in Brazil's economic activities - C2.4

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,42	2,04
Mining and Quarrying	2	1,76	1,81	2,97
Food, Beverages and Tobacco	3	-1,16	-2,62	-125,38
Textiles and Textile Products	4	-2,06	-3,47	-68,29
Leather, Leather and Footwear	5	-3,36	-4,74	-41,12
Wood and Products of Wood and Cork	6	-4,20	-5,59	-33,26
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-2,64	-5639,30
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,82	-22,58
Chemicals and Chemical Products	9	-1,23	-3,08	-150,82
Rubber and Plastics	10	-2,21	-3,46	-56,57
Other Non-Metallic Mineral	11	-1,07	-2,95	-175,73
Basic Metals and Fabricated Metal	12	-2,93	-4,30	-46,81
Machinery, Nec	13	-0,68	-2,14	-214,23
Electrical and Optical Equipment	14	-3,99	-5,95	-49,24
Transport Equipment	15	0,00	-0,92	-29533,85
Manufacturing, Nec; Recycling	16	-1,14	-2,91	-154,87
Electricity, Gas and Water Supply	17	0,36	0,38	7,25
Construction	18	0,19	0,22	14,55
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,82	-6,80
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,02
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,26	-0,83
Hotels and Restaurants	22	1,72	1,77	2,65
Inland Transport	23	0,32	0,48	52,04
Water Transport	24	-4,22	-4,05	4,02
Air Transport	25	-3,41	-3,29	3,42
Other Supporting and Auxiliary Transport (...)	26	0,50	0,66	32,84
Post and Telecommunications	27	3,58	3,75	4,76
Financial Intermediation	28	2,49	2,34	-5,91
Real Estate Activities	29	1,37	1,32	-3,58
Renting of M Eq and Other (...)	30	1,60	1,76	9,83
Public Admin and Defence; (...)	31	1,76	1,83	4,22
Education	32	1,01	1,02	1,34
Health and Social Work	33	1,35	1,37	1,66
Other Community, Social and Personal (...)	34	1,54	1,69	9,25

Table 2.38: Capital and labor intensities in Brazil's economic activities - C2.4

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,88	0,67	0,13	0,12	-4,46
Textiles and Textile Products	4	0,69	0,72	4,40	0,31	0,28	-9,96
Leather, Leather and Footwear	5	0,75	0,75	0,35	0,25	0,25	-1,05
Wood and Products of Wood and Cork	6	0,68	0,75	10,15	0,32	0,25	-22,01
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,83	13,65	0,27	0,17	-37,57
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,90	-5,16	0,05	0,10	99,34
Chemicals and Chemical Products	9	0,82	0,82	-0,63	0,18	0,18	2,97
Rubber and Plastics	10	0,77	0,75	-2,96	0,23	0,25	10,01
Other Non-Metallic Mineral	11	0,72	0,76	5,03	0,28	0,24	-12,91
Basic Metals and Fabricated Metal	12	0,79	0,81	2,10	0,21	0,19	-7,96
Machinery, Nec	13	0,74	0,76	2,53	0,26	0,24	-7,19
Electrical and Optical Equipment	14	0,81	0,83	2,40	0,19	0,17	-10,12
Transport Equipment	15	0,82	0,76	-6,64	0,18	0,24	29,48
Manufacturing, Nec; Recycling	16	0,72	0,79	9,66	0,28	0,21	-24,97
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.39: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.4

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,33	1,58	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-1,99	-112,00	0,79	0,79	0,50	0,21	0,21	-1,86
Services	1,78	1,80	0,94	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,15	-75,33	0,62	0,62	0,30	0,38	0,38	-0,49

Table 2.40: Annualized growth rates of TFP in Brazil's economic activities - C2.5

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,43	2,32
Mining and Quarrying	2	1,76	1,74	-0,75
Food, Beverages and Tobacco	3	-1,16	-2,95	-153,23
Textiles and Textile Products	4	-2,06	-2,54	-23,03
Leather, Leather and Footwear	5	-3,36	-5,10	-51,82
Wood and Products of Wood and Cork	6	-4,20	-6,28	-49,64
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-0,74	-1510,91
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-2,46	-7,05
Chemicals and Chemical Products	9	-1,23	-2,98	-143,09
Rubber and Plastics	10	-2,21	-4,64	-109,73
Other Non-Metallic Mineral	11	-1,07	-2,55	-138,75
Basic Metals and Fabricated Metal	12	-2,93	-5,65	-92,94
Machinery, Nec	13	-0,68	-2,36	-245,47
Electrical and Optical Equipment	14	-3,99	-4,88	-22,36
Transport Equipment	15	0,00	-2,33	-74918,07
Manufacturing, Nec; Recycling	16	-1,14	-2,73	-139,42
Electricity, Gas and Water Supply	17	0,36	0,34	-4,47
Construction	18	0,19	0,20	2,76
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,58	-0,11
Wholesale Trade and Commission Trade (...)	20	2,14	2,14	-0,33
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,27	-0,46
Hotels and Restaurants	22	1,72	1,78	3,63
Inland Transport	23	0,32	0,30	-4,29
Water Transport	24	-4,22	-4,24	-0,46
Air Transport	25	-3,41	-3,42	-0,30
Other Supporting and Auxiliary Transport (...)	26	0,50	0,48	-3,47
Post and Telecommunications	27	3,58	3,57	-0,38
Financial Intermediation	28	2,49	2,48	-0,18
Real Estate Activities	29	1,37	1,36	-0,64
Renting of M Eq and Other (...)	30	1,60	1,59	-0,74
Public Admin and Defence; (...)	31	1,76	1,76	0,09
Education	32	1,01	1,01	-0,31
Health and Social Work	33	1,35	1,36	0,61
Other Community, Social and Personal (...)	34	1,54	1,53	-0,72

Table 2.41: Capital and labor intensities in Brazil's economic activities - C2.5

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,97	11,34	0,13	0,03	-75,70
Textiles and Textile Products	4	0,69	0,70	1,19	0,31	0,30	-2,69
Leather, Leather and Footwear	5	0,75	0,70	-6,99	0,25	0,30	21,20
Wood and Products of Wood and Cork	6	0,68	0,66	-3,40	0,32	0,34	7,37
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,69	-6,40	0,27	0,31	17,62
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,82	-13,83	0,05	0,18	266,15
Chemicals and Chemical Products	9	0,82	0,83	0,69	0,18	0,17	-3,23
Rubber and Plastics	10	0,77	0,77	-0,24	0,23	0,23	0,82
Other Non-Metallic Mineral	11	0,72	0,70	-2,08	0,28	0,30	5,34
Basic Metals and Fabricated Metal	12	0,79	0,78	-1,42	0,21	0,22	5,37
Machinery, Nec	13	0,74	0,71	-4,61	0,26	0,29	13,10
Electrical and Optical Equipment	14	0,81	0,64	-20,22	0,19	0,36	85,14
Transport Equipment	15	0,82	0,85	4,71	0,18	0,15	-20,92
Manufacturing, Nec; Recycling	16	0,72	0,61	-15,67	0,28	0,39	40,53
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.42: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.5

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,25	-4,71	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-2,01	-114,47	0,79	0,78	-0,62	0,21	0,22	2,30
Services	1,78	1,75	-1,72	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	0,04	-93,82	0,62	0,62	-0,39	0,38	0,38	0,63

Table 2.43: Annualized growth rates of TFP in Brazil's economic activities - C2.6

		Annualized TFP Growth Rates		
Activity		model	counterf	change (%)
Agriculture, Hunting, Forestry and Fishing	1	1,39	1,57	12,44
Mining and Quarrying	2	1,76	6,49	269,88
Food, Beverages and Tobacco	3	-1,16	-5,56	-377,48
Textiles and Textile Products	4	-2,06	-4,44	-115,53
Leather, Leather and Footwear	5	-3,36	-6,82	-103,10
Wood and Products of Wood and Cork	6	-4,20	-8,64	-105,88
Pulp, Paper, Paper, Printing and Publishing	7	-0,05	-3,73	-8031,27
Coke, Refined Petroleum and Nuclear Fuel	8	-2,30	-6,01	-161,32
Chemicals and Chemical Products	9	-1,23	-5,60	-356,21
Rubber and Plastics	10	-2,21	-6,50	-193,78
Other Non-Metallic Mineral	11	-1,07	-5,12	-379,01
Basic Metals and Fabricated Metal	12	-2,93	-6,97	-138,03
Machinery, Nec	13	-0,68	-4,14	-507,23
Electrical and Optical Equipment	14	-3,99	-7,09	-77,96
Transport Equipment	15	0,00	-3,64	-117018,74
Manufacturing, Nec; Recycling	16	-1,14	-4,85	-324,82
Electricity, Gas and Water Supply	17	0,36	0,35	-2,53
Construction	18	0,19	0,17	-9,91
Sale, Maintenance and Repair of Motor (...)	19	-3,58	-3,81	-6,63
Wholesale Trade and Commission Trade (...)	20	2,14	2,15	0,09
Retail Trade, Except of Motor Vehicles (...)	21	1,28	1,26	-0,83
Hotels and Restaurants	22	1,72	1,81	5,29
Inland Transport	23	0,32	0,47	48,79
Water Transport	24	-4,22	-4,06	3,67
Air Transport	25	-3,41	-3,30	3,28
Other Supporting and Auxiliary Transport (...)	26	0,50	0,65	30,09
Post and Telecommunications	27	3,58	3,74	4,52
Financial Intermediation	28	2,49	2,34	-5,98
Real Estate Activities	29	1,37	1,32	-4,02
Renting of M Eq and Other (...)	30	1,60	1,75	9,29
Public Admin and Defence; (...)	31	1,76	1,84	4,52
Education	32	1,01	1,03	1,58
Health and Social Work	33	1,35	1,39	2,62
Other Community, Social and Personal (...)	34	1,54	1,68	8,72

Table 2.44: Capital and labor intensities in Brazil's economic activities - C2.6

		Capital Intensity			Labor Intensity		
Activity		model	counterf	(%)	model	counterf	(%)
Agriculture, Hunting, Forestry and Fishing	1	0,61	0,61	0,00	0,39	0,39	0,00
Mining and Quarrying	2	0,81	0,81	0,00	0,19	0,19	0,00
Food, Beverages and Tobacco	3	0,87	0,84	-3,25	0,13	0,16	21,68
Textiles and Textile Products	4	0,69	0,72	3,46	0,31	0,28	-7,82
Leather, Leather and Footwear	5	0,75	0,69	-7,81	0,25	0,31	23,70
Wood and Products of Wood and Cork	6	0,68	0,75	9,72	0,32	0,25	-21,08
Pulp, Paper, Paper, Printing and Publishing	7	0,73	0,73	-0,68	0,27	0,27	1,88
Coke, Refined Petroleum and Nuclear Fuel	8	0,95	0,92	-3,43	0,05	0,08	66,05
Chemicals and Chemical Products	9	0,82	0,81	-1,54	0,18	0,19	7,18
Rubber and Plastics	10	0,77	0,74	-3,58	0,23	0,26	12,11
Other Non-Metallic Mineral	11	0,72	0,72	0,39	0,28	0,28	-0,99
Basic Metals and Fabricated Metal	12	0,79	0,71	-10,21	0,21	0,29	38,69
Machinery, Nec	13	0,74	0,72	-3,08	0,26	0,28	8,74
Electrical and Optical Equipment	14	0,81	0,66	-18,85	0,19	0,34	79,37
Transport Equipment	15	0,82	0,79	-3,65	0,18	0,21	16,18
Manufacturing, Nec; Recycling	16	0,72	0,67	-7,13	0,28	0,33	18,45
Electricity, Gas and Water Supply	17	0,72	0,72	0,00	0,28	0,28	0,00
Construction	18	0,65	0,65	0,00	0,35	0,35	0,00
Sale, Maintenance and Repair of Motor (...)	19	0,39	0,39	0,00	0,61	0,61	0,00
Wholesale Trade and Commission Trade (...)	20	0,49	0,49	0,00	0,51	0,51	0,00
Retail Trade, Except of Motor Vehicles (...)	21	0,35	0,35	0,00	0,65	0,65	0,00
Hotels and Restaurants	22	0,68	0,68	0,00	0,32	0,32	0,00
Inland Transport	23	0,56	0,56	0,00	0,44	0,44	0,00
Water Transport	24	0,70	0,70	0,00	0,30	0,30	0,00
Air Transport	25	0,57	0,57	0,00	0,43	0,43	0,00
Other Supporting and Auxiliary Transport (...)	26	0,62	0,62	0,00	0,38	0,38	0,00
Post and Telecommunications	27	0,74	0,74	0,00	0,26	0,26	0,00
Financial Intermediation	28	0,55	0,55	0,00	0,45	0,45	0,00
Real Estate Activities	29	0,63	0,63	0,00	0,37	0,37	0,00
Renting of M Eq and Other (...)	30	0,54	0,54	0,00	0,46	0,46	0,00
Public Admin and Defence; (...)	31	0,37	0,37	0,00	0,63	0,63	0,00
Education	32	0,26	0,26	0,00	0,74	0,74	0,00
Health and Social Work	33	0,49	0,49	0,00	0,51	0,51	0,00
Other Community, Social and Personal (...)	34	0,46	0,46	0,00	0,54	0,54	0,00

Table 2.45: Annualized growth rates of TFP and capital/labor intensities in Brazil's 3 sectors and total - C2.6

	annual growth			capital intensity			labor intensity		
	model	counterf	change (%)	model	counterf	change (%)	model	counterf	change (%)
Agriculture	1,31	1,43	8,89	0,61	0,61	0,00	0,39	0,39	0,00
Industry	-0,94	-3,79	-304,41	0,79	0,76	-3,51	0,21	0,24	13,12
Services	1,78	1,78	-0,36	0,47	0,47	0,00	0,53	0,53	0,00
Total	0,60	-0,73	-221,92	0,62	0,61	-2,06	0,38	0,39	3,37

Capítulo 3

Determinantes do Crescimento Econômico da América Latina

3.1 Introdução

Uma grande parcela dos países pertencentes à região da América Latina e Caribe (LAC) registrou desempenho excelente em termos de crescimento econômico na última década. Contudo, não existe ainda consenso acerca de quais foram os principais determinantes para esta fase de grande expansão econômica. Se, por um lado, pode-se argumentar que ela foi apenas reflexo de condições externas favoráveis - principalmente devido à elevação do preço das commodities no período entre 2000 e 2011, principal componente das exportações da região - por outro, a mais recente fase de aceleração do crescimento dos membros da LAC pôde ter sido consequência direta de importantes reformas econômicas que vinham ocorrendo nesses países.

No mais, a partir dos últimos anos da década passada, o crescimento do PIB começou a desacelerar, possivelmente refletindo uma piora do quadro internacional. Quais fatores vêm, de fato, impactando as taxas de crescimento do PIB nesta região, nos últimos anos? Qual a importância relativa de políticas públicas e da alteração das condições externas, para o crescimento dos países latino-americanos?

O presente trabalho tentará elucidar estas questões, uma vez que consideramos ser de extrema importância compreender adequadamente o que contribuiu para o crescimento da última década, de maneira a construírmos um arcabouço consistente, que permita à região enfrentar futuros períodos de recessão e crise.

Dessa forma, são três os principais objetivos que perseguiremos: (i) descrever as principais características do crescimento econômico da América Latina e Caribe (LAC), (ii) investigar os principais determinantes do crescimento econômico desta região, levando em conta alterações no ambiente econômico da última década, (iii) contrastar a importância relativa de condições externas favoráveis com a de políticas públicas adequadas para o crescimento econômico na LAC.

O artigo está organizado da seguinte forma: na Seção 2, forneceremos alguns fatos estilizados concernentes ao crescimento econômico dos países da LAC, contrastando-os entre si e com outras regiões do mundo, além de explicitarmos a importância individual de cada categoria de determinantes do crescimento econômico e apresentarmos as proxies que usaremos em nossa análise empírica.

Na Seção 3, trataremos da estimação de uma equação de regressão de crescimento econômico, desde o detalhamento da amostra, passando pela descrição detalhada da metodologia de estimação que adotamos e concluindo com a apresentação dos principais resultados.

Na Seção 4, utilizaremos nossas estimativas para avaliarmos tanto a contribuição de cada grupo de determinantes para a variação esperada do crescimento econômico de cada país quanto a capacidade do modelo que propomos em explicar o crescimento econômico dos países. Por fim,

faremos um pequeno exercício contrafactual, buscando responder à seguinte pergunta: em que medida os termos de troca favoráveis foram responsáveis pela elevação das taxas de crescimento entre a primeira e a segunda metades da década de 2000 na região da LAC? A Seção 5 conclui.

3.2 Determinantes do Crescimento Econômico

3.2.1 Fatos Estilizados

O quão semelhantes são os países da LAC em termos de padrão de crescimento econômico? É correto falar em tendências comuns? Quais são as exceções mais marcantes? Como o desempenho da região da LAC se compara ao de outras regiões do mundo? Nesta seção, apresentaremos alguns fatos estilizados, objetivando lançar luz sobre esses e outros questionamentos.

PIB per Capita Real e Taxas de Crescimento Anuais do PIB - Países Selecionados

A última década foi extremamente promissora para os países da região da América Latina e Caribe (LAC), em termos de evolução do crescimento econômico. Conforme podemos observar na Figura 1, as economias da Argentina, Brasil, Chile, Uruguai, Venezuela, Peru, México e Panamá sustentaram uma tendência crescente nos níveis de PIB real per capita desde 2000.

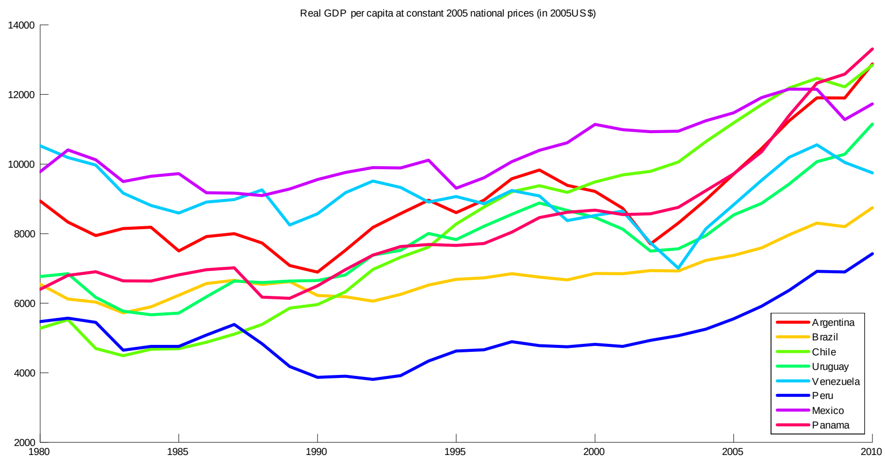


Figure 3.1: PIB per capita real de países selecionados da LAC

No entanto, é possível notar na Figura 2, que traz as taxas de crescimento anuais do PIB per capita real de países selecionados da LAC, uma nítida desaceleração do crescimento do PIB na região, a partir dos últimos anos da década passada.

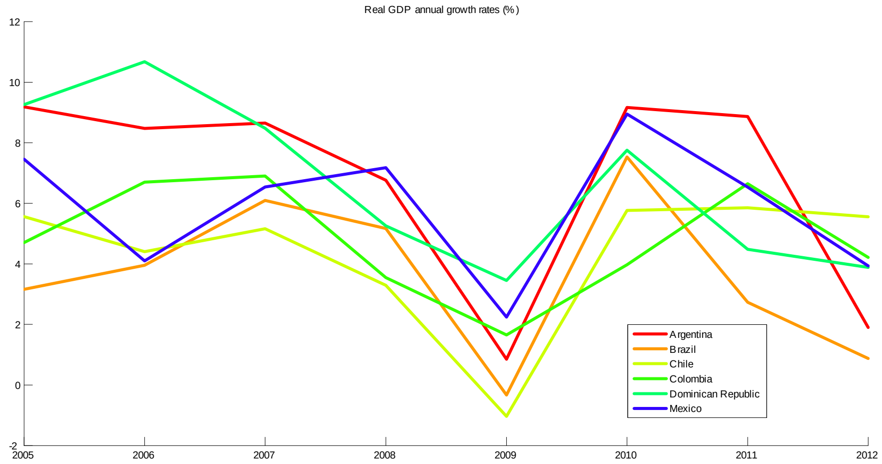


Figure 3.2: Taxas de Crescimento do PIB per capita, por região e por década - 1961-2010

Taxas de Crescimento do PIB per Capita por Região e por Década (1961-2010)

Conforme podemos observar na Figura 3, a taxa de crescimento do PIB per capita mundial (representada pela barra vermelha) esteve em trajetória de queda entre 1960 e 1990. Entre 1991 e 2000, contudo, observamos que esta taxa mais do que triplicou em relação à da década anterior, conseguindo se sustentar em aproximadamente 2% a.a. entre 2001 e 2010. No entanto, diferentes regiões experimentaram trajetórias distintas de crescimento ao longo desses 50 anos.

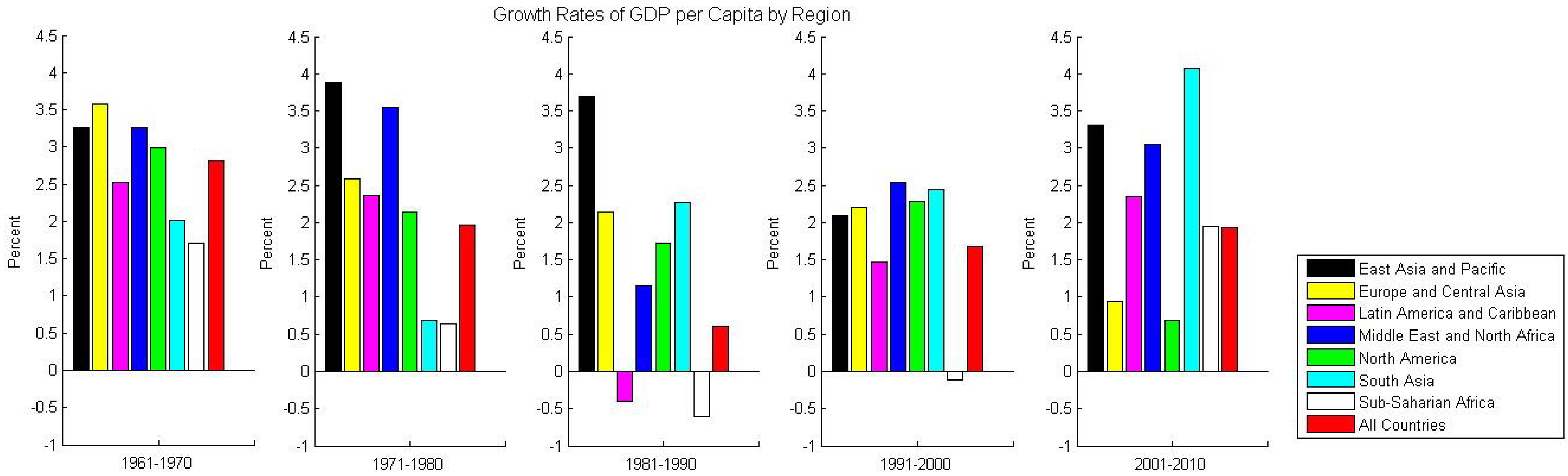


Figure 3.3: Taxas de Crescimento do PIB per capita, por região e por década - 1961-2010

A taxa de crescimento do PIB per capita da região da "Europa e Ásia Central" (barra amarela), que na década de 1960 foi a maior dentre as de todas as regiões consideradas, exibiu uma nítida trajetória de queda, chegando a ficar à frente apenas da "América do Norte" (barra verde) - que seguiu trajetória similar - entre 2001 e 2010.

Por sua vez, na região do "Sul da Ásia" (barra azul clara), o crescimento do PIB per capita foi o segundo mais baixo na década de 1960 (à frente apenas da "África Subsaariana"), chegando a se tornar ainda cerca de quatro vezes menor na década seguinte. Entretanto, já na década de 1980 esta taxa superou seu patamar inicialmente observado, mantendo-se alta na década de 1990 e aproximadamente dobrando na década seguinte, quando o conjunto dos países sul-asiátivos registrou o maior crescimento econômico entre todas as regiões do mundo.

No que se refere às taxas de crescimento da "Ásia Ocidental e Pacífico" (barra preta), podemos destacar que elas mantiveram-se altas ao longo dos 50 anos analisados, sofrendo apenas uma pequena queda na década de 1990, não suficiente, porém, para abalar sua importância relativa. Entre 2001-2010, esta região obteve o segundo melhor resultado de crescimento dentre todas as analisadas.

Por fim, note que as regiões da "América Latina e Caribe" (barra rosa), "Oriente Médio e África do Norte" (barra azul escura) e "África Subsaariana" (barra branca) registraram seus piores desempenhos na década de 1980, conseguindo gradativamente recuperar-se desde então. Apenas em 2001-2010, contudo, foram capazes de retornar ao patamar de crescimento da década de 1960.

Taxas de Crescimento do PIB per Capita nos Países da LAC (1961-2010)

A Figura 4 nos mostra a taxa de crescimento do PIB per capita para a região da América Latina e Caribe e para alguns países selecionados. Conforme podemos notar, Brasil, Chile e Costa Rica cresceram a taxas superiores às da região, enquanto os piores desempenhos podem ser observados para Bolívia, Peru e Venezuela.

Frequentemente, a década de 1980 é chamada de "a década perdida" do crescimento para a América Latina, uma vez que quase a totalidade dos países latino-americanos continentais exibiram taxas de crescimento negativas ou muito próximas de zero. As únicas exceções foram o Chile e a Colômbia (ver Figuras 5 e 6).

Já na década de 1991-2000, observamos um período de franca recuperação para a maioria dos países, exceto para a própria Colômbia, Venezuela e Paraguai. Em alguns países como Argentina, Uruguai, Bolívia e Peru, as taxas de crescimento econômico retornaram para os patamares mais elevados, observados nas décadas de 1960 e 1970, ou até mesmo os suplantaram. Conforme verificamos na Figura 5, o mesmo não ocorreu no Brasil.

Na década de 2001-2010, as taxas de crescimento foram ainda maiores para 12 dos 16 países da LAC continental analisados. As exceções estão concentradas na América Central, e são El Salvador, Guatemala e México, conforme podemos observar na Figura 7; na América do Sul, apenas no Chile observou-se declínio do crescimento per capita, de acordo com o segundo painel da Figura 5.

As Figuras 8, 9 e 10 nos mostram que o padrão do crescimento econômico foi menos uniforme entre os membros da região do Caribe. De maneira similar à região da América Latina, alguns países caribenhos, como Suriname (painel à direita na Figura 8), República Dominicana e Trinidade e Tobago (terceiro e quarto painéis da Figura 9), também sofreram um período de contração econômica na década de 1980, e conseguiram se recuperar na de 1990.

Já nas Bahamas e Jamaica (respectivamente, primeiro e quarto painéis da Figura 9) e em todas as chamadas "pequenas ilhas" (Figura 10), as taxas de crescimento na década de 1990 foram inferiores às observadas na década anterior. Em suma, na maior parte destes países, a década de 2000 foi marcada por uma continuação da retração no crescimento, exceto em Suriname, Trinidade e Tobago, Antigua e Barbuda, Dominica e Santa Lucia.

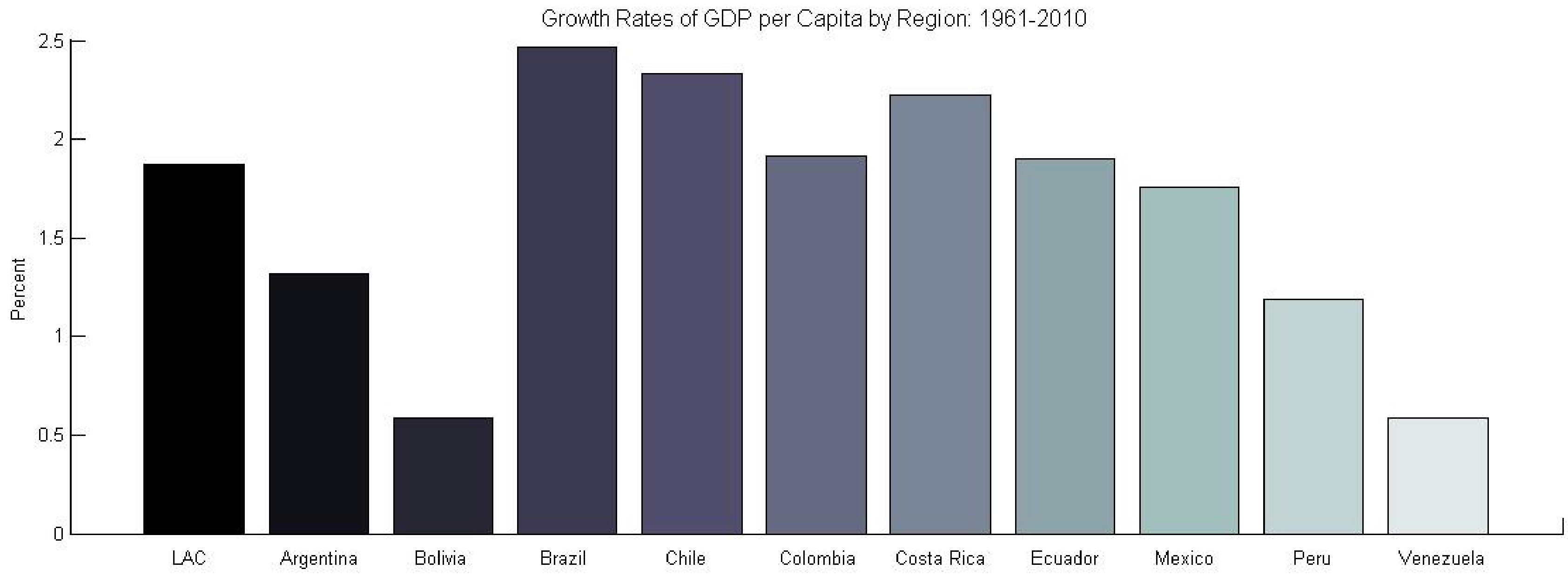


Figure 3.4: Taxas de Crescimento do PIB per capita, - América Latina e Países Selecionados

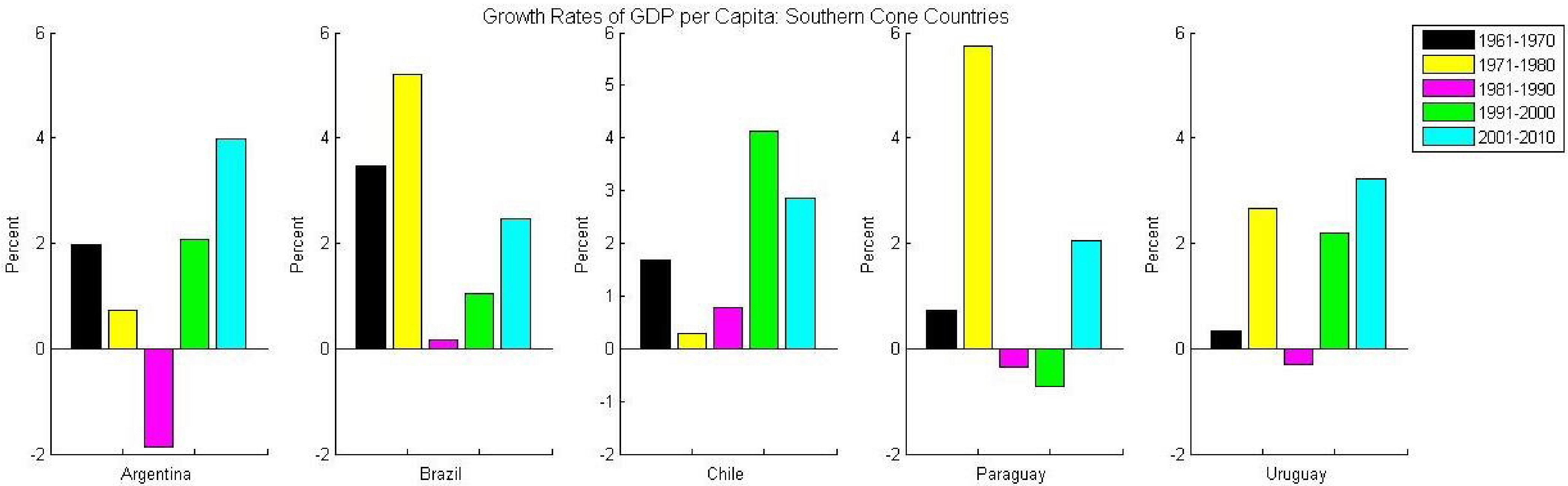


Figure 3.5: Taxas de Crescimento do PIB per capita: Cone Sul

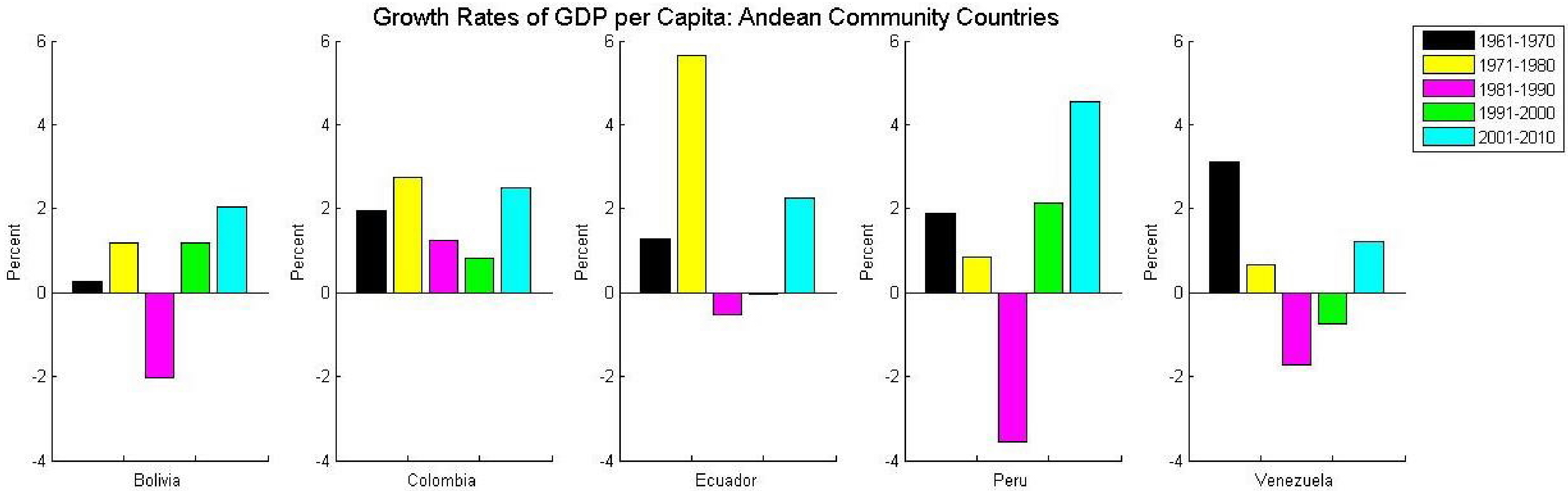


Figure 3.6: Taxas de Crescimento do PIB per capita: Comunidade Andina

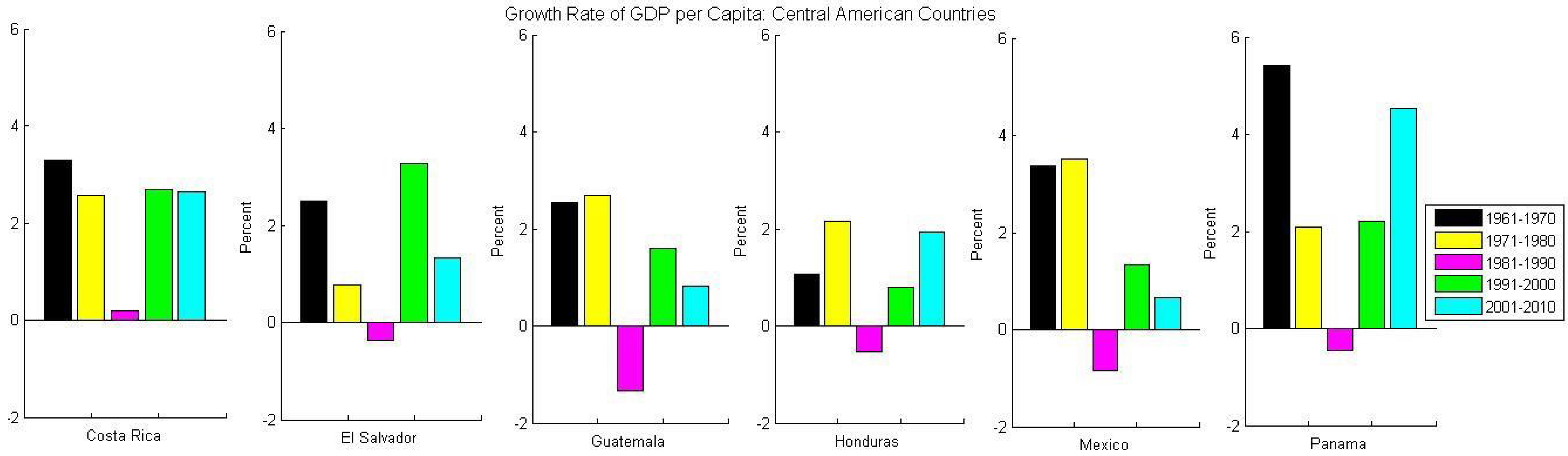


Figure 3.7: Taxas de Crescimento do PIB per capita: América Central

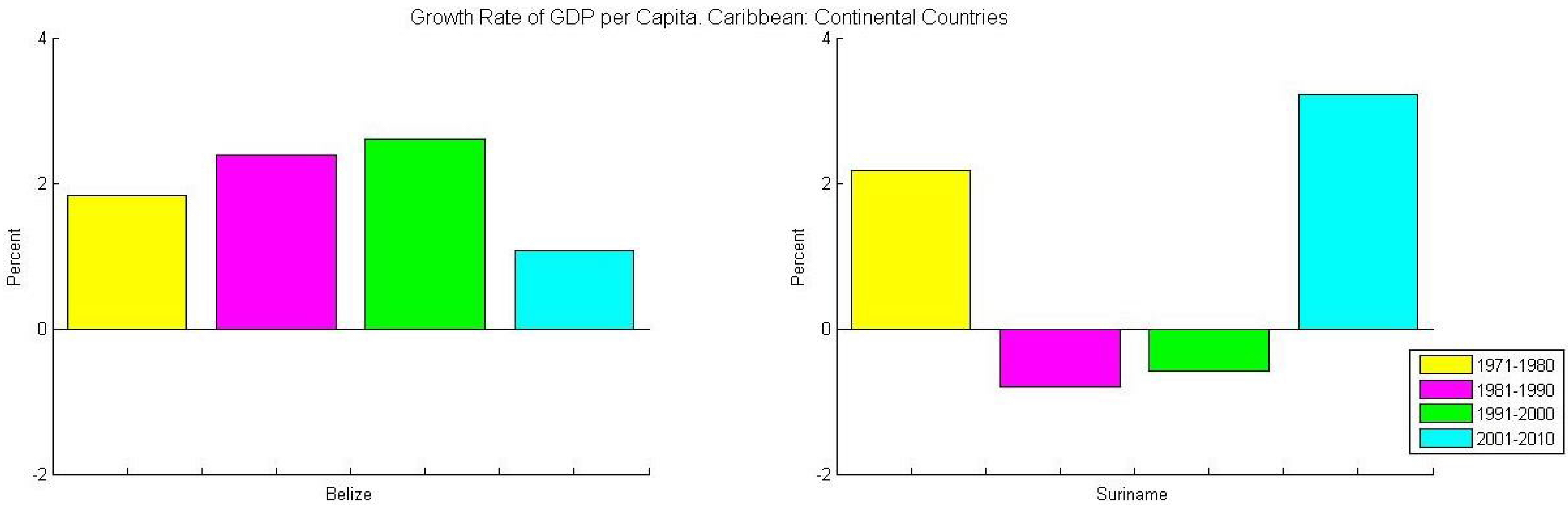


Figure 3.8: Taxas de Crescimento do PIB per capita: Caribe Continental

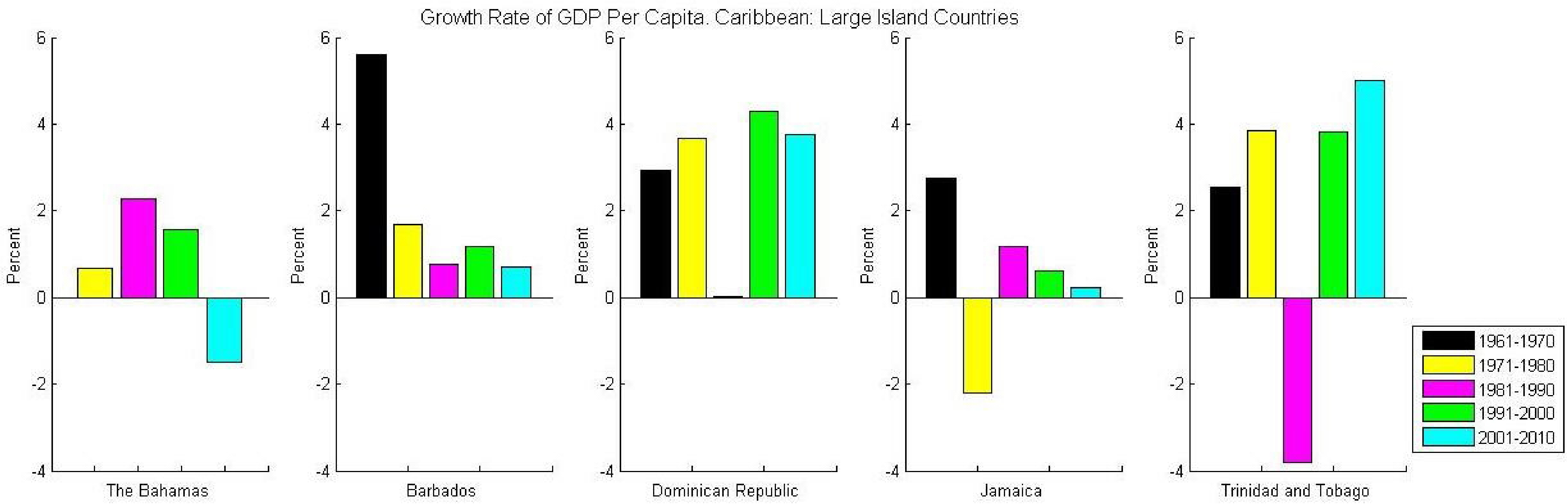


Figure 3.9: Taxas de Crescimento do PIB per capita: Caribe - Grandes Ilhas

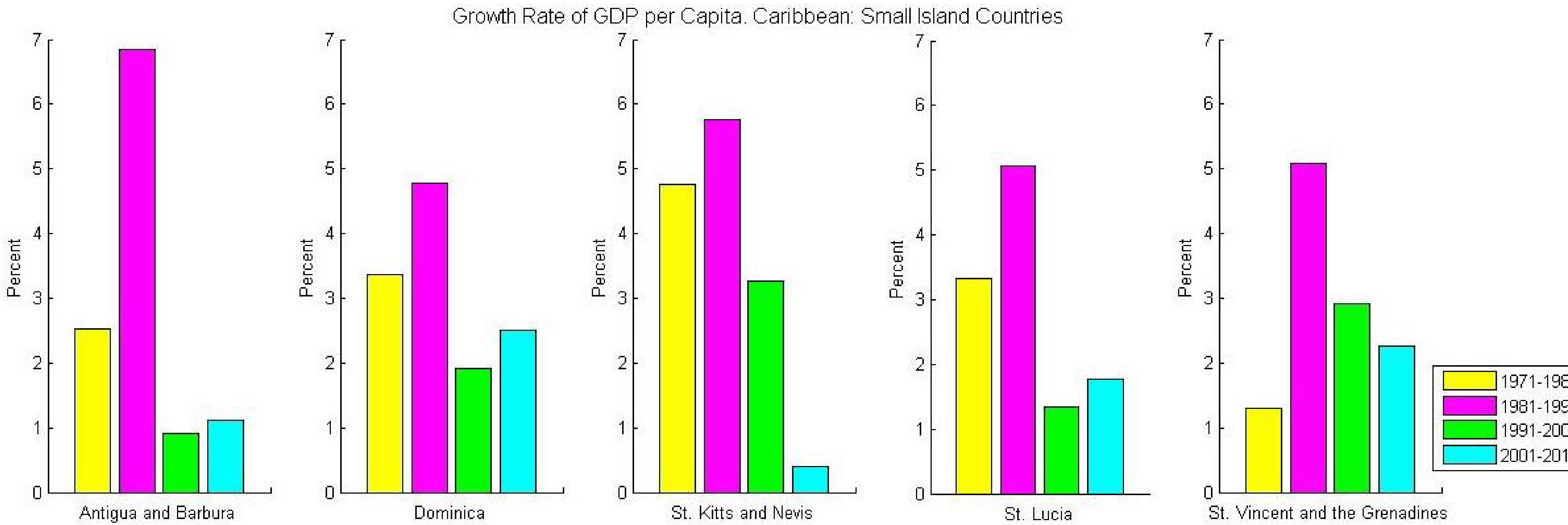


Figure 3.10: Taxas de Crescimento do PIB per capita: Caribe - Pequenas Ilhas

Uma vez detectadas essas similaridades e diferenças no crescimento econômico dos membros da LAC, buscaremos compreender se elas se deveram a reestruturações internas nas políticas econômicas e sociais destes países ou a condições externas a eles impostas, que possam tê-los afetado individualmente, ou em conjunto, nos países que apresentem características semelhantes.

Visando a elucidar essas questões, buscaremos explicar o desempenho econômico de alguns selecionados países da LAC, ao longo do tempo. Para tanto, lançaremos mão de técnicas econométricas no estado da arte, que nos ajudam a lidar com potenciais problemas advindos da análise de dados em painel. A exemplo do que fizeram de Barro e Lee (1994), Esterly, Loyaza and Montiel (1997), Loyaza, et al (2005), entre outros, nossa contribuição objetiva lançar luz sobre as relações intrínsecas entre algumas variáveis econômicas, políticas e sociais e o crescimento econômico de uma ampla amostra de países.

3.2.2 Variáveis de Interesse

Diversas variáveis de cunho político, social e econômico foram apontadas nas últimas décadas como potenciais determinantes do crescimento econômico. A título de ilustração, Durlauf, Johnson, and Temples (2005) identificaram 43 teorias de crescimento econômico diferentesCada uma dessas teorias foi estatisticamente significante em pelo menos um estudo., as quais propunham, no total, 145 variáveis distintas como proxies de determinantes do crescimento.

O presente estudo, ao se caracterizar como uma investigação empírica, encontra-se restrito à disponibilidade de dados. Objetivando manter o maior número possível de observações em nossa amostra, optamos por eleger um subconjunto das variáveis apontadas por Loayza, et al. (2005) como possíveis determinantes do crescimento. No entanto, ainda que algumas variáveis explicativas tenham sido excluídas da análise, acreditamos que as mais relevantes para um modelo tão simples quanto possível puderam ser mantidas, de maneira que ainda podemos dividi-las nas cinco categorias propostas pelos autores - Convergência Transicional, Reversão Cíclica, Políticas Estruturais, Políticas de Estabilização e Condições Externas.

Nesta seção, explicitaremos a potencial importância individual de cada uma destas categorias para o crescimento econômico dos países, fornecendo uma breve revisão da literatura afim com o objetivo de justificar cada escolha de variáveis explicativas. No mais, apresentaremos cada uma destas variáveis, as quais utilizaremos como proxies em nossa equação de regressão de crescimento.

Todas as séries que utilizamos, assim como as bases de dados em que elas podem ser obtidas, encontram-se detalhadas na Tabela 1:

Table 3.1: Variáveis de Interesse

GRUPO	SUBGRUPO	PROXY	VARIÁVEL	FONTE
Convergência Transicional		initial level of GDP per capita - in logs	rgdpna: Real GDP at constant 2005 national prices (2005US$)/ Population (total)	Elaboração própria a partir da PWT 8.0 e da World Development Indicators Database (WB)
Reversão Cíclica		initial output gap		Elaboração própria a partir da PWT 8.0 e da World Development Indicators
Políticas Estruturais	Educação	average years of total schooling - in logs		Barro and Lee (2013). A new data set of educational attainment in the world, 1950 2010.
	Desenvolvimento Financeiro	private domestic credit/GDP (%) - in logs	Domestic credit to private sector (% of GDP)	Elaboração própria a partir da World Development Indicators Database (WB)
	Abertura Comercial	trade volume/GDP (%) - in logs	(Exports of goods and services + Imports of goods and services)/GDP	Elaboração própria a partir da World Development Indicators Database (WB)
	Fardo Governamental	government consumption/GDP (%) - in logs	General government final consumption expenditure (% of GDP)	Development Indicators Database (WB) Elaboração própria a partir da World Development Indicators Database (WB)
	Infraestrutura	telephone lines/1000hab - in logs	Telephone lines and Population (total)	Elaboração própria a partir da World Development Indicators Database (WB)

GRUPO	SUBGRUPO	PROXY	VARIÁVEL	FONTE
Políticas de Estabilização	Ausência de estabilidade de preços	inflation rate - (log((1+dp)*100)	Inflation, consumer prices (annual %) and CPI % Change	Elaboração própria a partir da World Development Indicators Database (WB) e da UNData.
	Ausência de estabilidade do produto	standard deviation of the output gap for the period		Elaboração própria a partir da PWT 8.0 e da World Development Indicators Database (WB)
Condições Externas	Choques nos termos-de-troca	log difference of terms-of-trade	Net barter terms of trade index (2000 = 100) and Export Unit Value (Export Prices)/Import Unit Value (Import Prices)	Elaboração própria a partir da World Development Indicators Database (WB) e da UNData.
	Period-specific shifts	time dummy variables		Elaboração própria.

Convergência Transicional

A primeira variável que consideraremos um dos motores para o crescimento econômico será uma proxie para convergência condicional.

O modelo neoclássico de crescimento - ou mesmo modelos de crescimento endógeno que exibam alguma forma de dinâmica de transição - traz como uma de suas principais implicações a chamada "convergência condicional" (Mankiw, 1995). Isso significa dizer que cada economia converge para o seu próprio estado estacionário, e que a velocidade dessa convergência é negativamente relacionada à distância em que a economia se encontra do mesmo.

Ou seja, esses modelos prevêem que um valor inicial mais baixo de renda per capita tende a gerar uma maior taxa de crescimento da renda per capita, uma vez que se controle para os determinantes do estado estacionário. (Barro and Sala-i-Martin, 2004). Em outras palavras, se se verifica a convergência condicionalTambém conhecida como \beta-converg\hat{e}ncia

ou reversão à média., então países pobres tendem a crescer a maiores taxas do que os países ricos, tudo o mais constante.

A relação negativa entre a taxa de crescimento econômico e o produto per capita inicial, contudo, se dá como consequência da adoção de uma função de produção com retornos constantes de escala em relação ao capital e ao trabalho. Modelos construídos a partir de uma função de produção com retornos crescentes de escala, em seu turno, implicam em uma relação positiva entre as duas variáveis, sugerindo divergência (Romer, 1990).

Alguns autores, como Barro (1991) e Mankiw et al. (1992), testaram a hipótese de convergência condicional. Embora tenham analisado amostras distintas, suas regressões apontaram para uma taxa de convergência de cerca de 2% ao ano, o que implica em uma "vida-média" de 35 anos; (isto é, tempo para reduzir à metade a distância ao estado estacionário).

No entanto, conforme aponta Mankiw (1995), embora esses resultados sejam qualitativamente consistentes com o modelo neoclássico, a taxa de convergência obtida por meio de estimativas empíricas é aproximadamente a metade do que o modelo prevê. Segundo este autor, "na prática, as economias de fato regridem em direção à suas médias condicionais, mas apenas lentamente. A condição inicial de uma economia faz diferença por muito mais tempo do que o modelo diz que ela deveria fazer".Mankiw (1995). Tradução própria.

Isso posto, ao incluirmos o (log do) PIB per capita no início do período como uma das variáveis explicativas da regressão estimada, controlamos para a posição inicial da economia. A partir do coeficiente estimado, poderemos, portanto, extrair alguma intuição a respeito da presença de convergência condicional para os países que compõem nossa amostra.

Reversão Cíclica

No capítulo 3, apontaremos as principais características da amostra que pautará toda a análise a ser desenvolvida, assim como detalharemos suas estatísticas descritivas mais relevantes. Conforme poderemos observar, os períodos nos quais serão baseadas tanto as estimações quanto as projeções constituir-se-ão, na verdade, por médias de 5 anos. Esse procedimento é relativamente padrão na literatura empírica de crescimento econômico pautada em dados em painel, e busca extrair das séries o componente meramente cíclico, dado que o foco dessa modalidade de estudo incide sobre tendências de longo prazo.

Todavia, mesmo após reduzirmos a frequência das séries do modo descrito, movimentos cíclicos ainda poderão exercer influência sobre os resultados da estimação, inclusive com potencial para alterar a magnitude do coeficiente da variável que utilizamos para controlar para convergência transicional e, consequentemente, superestimar a velocidade de convergência.

Uma forma de contornar esse obstáculo é, seguindo Loayza, et al. (2005), adicionar certos regressores que, embora não sejam comumente observados em trabalhos empíricos acerca de crescimento econômico, são capazes de captar boa parte da interferência dos ciclos de negócios sobre a tendência de crescimento dos países.

Visando a controlar para reversão cíclica (à tendência de crescimento), adicionamos o hiato do produto no início do período ao conjunto das variáveis explicativas. O hiato do produto é calculado por meio da diferença entre (o log) do PIB per capita observado e o potencial (ou médio), ambos no início de cada período.

Para decompor as séries de PIB per capita de cada um dos países em seus componentes cíclico e de tendência (potencial), fizemos uso do filtro Hodrick-Prescott.

Políticas Estruturais

Um dos principais desafios impostos à literatura de crescimento endógeno está em estabelecer quais políticas públicas afetam em maior magnitude a taxa de crescimento econômico, bem como a ordem em que elas devem ser colocadas em prática. Diferentemente de como em geral procedem os estudos teóricos, os quais se preocupam em listar as consequências de um número reduzido de políticas (ou mesmo o efeito isolado de uma política específica), trabalhos empíricos buscam elencar um conjunto exaustivo de determinantes (LOAYZA, et al. (2005)).

No que tange a políticas estruturais, cinco subgrupos serão analisadas nestre trabalho, quais sejam, "Infraestrutura", "Educação", "Desenvolvimento Financeiro", "Abertura Comercial" e "Fardo Governamental".

Infraestrutura O primeiro subgrupo de política estutural que destacaremos está relacionado à provisão de infraestrutura e serviços públicos. A importância da disponilibilidade dos mesmos para o crescimento econômico de longo prazo já foi vastamente investigada por estudos teóricos. Arrow and Kurz (1970), em trabalho seminal, incluíram capital público como insumo da função de produção agregada da economia, partindo do modelo de Ramsey com crescimento de longo-prazo exógeno (CALDERÓN AND SERVÉN (2010)).

Barro (1990), por sua vez, foi o primeiro a incorporar o setor público em um modelo de crescimento endógeno com retornos constantes de escala a um conceito "amplo" de capital . Na modelagem proposta, serviços públicos são financiados por meio de impostos e afetam a função de produção ou utilidade dos agentes. Ao figurarem diretamente como insumos na função de produção privada, assumem um papel produtivo que cria um elo potencialmente positivo entre o governo e o crescimento econômico. No mais, serviços públicos e infraestrutura podem afetar o crescimento seja entrando diretamente como insumos na função de produção, aumentando a produtividade total dos fatores, ou mesmo encorajando o investimento privado por meio da proteção a direitos de propriedade ((LOAYZA, et al. (2005)).

Mais recentemente, avolumaram-se trabalhos voltados ao entendimento analítico dessas questões. Baier and Glomm (2001) investigaram, por meio de um modelo de crescimento endógeno de um setor, os possíveis impactos sobre crescimento e bem-estar de diferentes políticas públicas, isto é, de diversas formas possíveis de atuação do governo no que se refere à coleta de rendimentos e alocação destes entre transferências, investimento público e gastos com bens e serviços. No modelo proposto, os rendimentos do governo provêm de impostos sobre trabalho e lucro, há investimento em infraestrutura pública e provisão de serviços voltados à melhoria do bem estar e permite-se que haja transferência de pagamentos às famílias e impostos distorcivos. Como difere sobremaneira da modelagem proposta por Barro (1990), novos insights podem ser alcançados a partir desta contribuição. Um resultado que merece destaque aponta que a taxa de crescimento econômico balanceado é função crescente do percentual de receita do governo direcionado à infraestrutura. Portanto, os desdobramentos em termos de crescimento e bem estar de investimentos crescentes em infraestrutura podem ser relevantes, ainda que haja, para tanto, uma redução na provisão de serviços públicos direcionados ao aumento da utilidade dos agentes.

Por sua vez, Ghosh and Roy (2004), também partindo de um modelo de crescimento endógeno, incluíram como insumos da função de produção, além de os tradicionais capital privado e trabalho, duas categorias de bens públicos: capital público, que pode ser acumulado (estradas,

rodovias, aeroportos e outras formas de infraestrutura não-rivais e não-excludentes; e serviços públicos, que não podem ser acumulados (manutenção da infraestrutura e de outros serviços, como "lei e ordem"). Eles concluíram que, quando o gasto público na economia descentralizada é financiado por meio de impostos proporcionais, a taxa de crescimento do PIB e as razões entre o gasto público e o PIB, entre o nível de investimento em capital público e o gasto público total e entre o nível de investimento em capital privado e o gasto total com bens privados são todos inferiores ao resultado ótimo, no equilíbrio. Em seu turno, a razão na qual o capital público e os serviços públicos são empregados na produção do bem final é maior no equilíbrio, sendo ela uma ferramenta utilizada pelo governo tanto para compensar parcialmente as escolhas não-ótimas do setor privado, quanto para afetar a taxa de crescimento econômico.

No que se refere à literatura empírica, nas duas últimas décadas grande esforço foi dedicado a compreender o efeitos de longo prazo da infraestrutura sobre crescimento econômico, produtividade e desigualdade. Calderón and Servén (2008b) fazem uma breve revisão destas contribuições, ressaltando a diversidade de dados, métodos empíricos e medidas de infraestruturas utilizados pelos autores da área. Destacam também que as abordagens mais comuns consistem em se estimar uma função de produção agregada (ou uma função custo) ou realizar regressões de crescimento, empregando como proxies desde indicadores físicos de infraestrutura até fluxos de dispêndio ou estoques de capital público. Os resultados dos trabalhos baseados em indicadores físicos de infraestrutura apontam que ela exerce efeito positivo de longo prazo no produto, na produtividade e nas taxas de crescimento destas variáveis.

No entanto, análises voltadas a compreender o impacto da infraestrutura sobre o crescimento econômico são muito menos numerosas do que aquelas que estudam seus desdobramentos sobre o produto. Tanto estudos que utilizam medidas de dispêndio ou densidade da infraestrutura (utilizando para tanto dados de transporte ou telecomunicações, por exemplo) quanto aqueles que constroem índices agregados, contudo, chegam à mesma conclusão: a infraestrutura exerce impacto positivo e significante sobre o GDP per capita (CALDERÓN AND SERVÉN, 2008a).

Por tudo isso, torna-se compreensível por que, cada vez mais, se difunde a percepção de que investimentos insuficientes em infraestrutura configuram-se como uma importante barreira ao crescimento dos países da América Latina. Uma importante contribuição no sentido de catalogar as principais tendências no desenvolvimento da infraestrutura nessa região - em termos de qualidade, quantidade e acessibilidade - foi feita por Calderón and Servén (2010). Os autores focam a análise em três setores-chave: telecomunicação, energia e transporte terrestre, comparando inicialmente a evolução de cada um deles na América Latina com a equivalente em três outras regiões (middle and high-income coutries of East Asia, middle-income countries excluding LAC countries e industrial countries (OECD)). A partir dos dados, verificou-se que houve ganhos nas três dimensões investigadas (qualidade, quantidade e acessibilidade) nos últimos 25 anos. No entanto, foi registrada também a existência de um substancial gap em relação às outras regiões em quase todas as dimensões e setores analisados.

Os autores realizam, em seguida, uma avaliação econométrica da contribuição da infraestrutura para o crescimento da América Latina.Neste sentido, a abordagem utilizada pelos autores em muito se assemelha a que adotamos neste trabalho. Para tanto, a partir de um painel dinâmico de dados abarcando mais de 100 países avaliados em 45 anos (representados também por períodos de médias de 5 anos) e da proposição de uma equação de regressão de crescimento, fazem uso do estimador GMM-IV sistêmico, proposto por Arellano and Bover (1995) e Blundell and Bond (1998). Dois índices alternativos são, então, construídos para quantidade de infraestruturaOs resultados principais são reportados para o índice que utiliza "total telephone lines (fixed and mobile) per 100 workers" como proxy para telecomunicação, sendo o segundo, que utiliza "main telephone lines" computado para fins de análise de robustez. Os autores destacam a correlação de 0.99 entre esses dois índices de quantidade de infraestrutura. e um para qualidade dos serviços de infraestrutura, por meio do método de "primeiro componente principal" e, controlando para uma série de outros fatoresSão também variáveis explicativas na

regressão de crescimento adotada medidas de capital humano, desenvolvimento financeiro, abertura comercial, qualidade institucional, ausência de estabilidade dos preços, peso governamental e choques nos termos de troca, além de o lag do nível do GDP por trabalhador (como forma de se captar convergência condicional)., mensura-se o impacto das duas dimensões da infraestrutura sobre o crescimento econômico dos países. É encontrada evidência robusta de que o desenvolvimento da infraestrutura afeta positivamente o crescimento econômico de longo prazo, e de que não há diferença significativa entre a magnitude deste impacto nos países da America Latina e nos de outras regiões. No mais, uma análise contrafactual sugere que haveria ganhos em termos de crescimento (chegando a 3% ao ano, em média), caso o gap de infraestrutura entre a América Latina e a demais regiões desaparecesse.

Como medida de infraestrutura, optamos por utilizar aquela que convencionalmente é adotada na literatura, linhas de telefoneEssa variável (telephone lines), à qual anteriormente se denominava main telephone lines, refere-se apenas a linhas fixas de telefone. por mil habitantes, uma proxy para capacidade de telecomunicação. Esta escolha se deve a uma análise de custo e benefício, tendo em vista a disponibilidade de dados. Se, por um lado, entendemos que a densidade de linhas telefônicas não se configura como sendo a maneira mais adequada de se representar a infraestrutura de um país ou região, por outro, pouco ou nada ganharíamos em adotar uma medida alternativa, seja em substituição a ela ou mesmo conjuntamente.

Em primeiro lugar, as séries históricas das outras variáveis que poderiam ser utilizadas - tais como total de rodovias, percentual de rodovias pavimentadas, produção de eletricidade, etc - via de regra apresentam, para uma quantidade relevante de países que compõem nosso painel, dados para períodos muito mais curtos do que as de linhas de telefone. No mais, as séries são altamente correlacionanadas (o coeficiente de correlação entre linhas de telefone e total de rodovias é 0.55; entre linhas de telefone e percentual de rodovias pavimentadas é 0.69 e entre linhas de telefone e produção de eletricidade é 0.87).

Além disso, conforme Calderón and Servén (2010) salientam, a correlação entre qualquer uma das variáveis e seu primeiro componente principal é de pelo menos 0.90 e a correlação entre as medidas de quantidade de infraestrutura e as de qualidade, para cada um dos setores, é de cerca de 0.50. Por fim, as medidas de quantidade e qualidade de infraestrutura possivelmente conseguem capturar a tendência do acesso à mesma, no sentido de que o acesso à infraestrutura geralmente é maior em países com maior disponibilidade e qualidade de infraestrutura (não justificando, portanto, a utilização dessa categoria de séries, que também apresenta maior escassez de dados).

Educação Outra importante categoria de política estrutural que consideraremos é educação, que será, para os fins desta investigação, uma proxy para capital humano. Desde a contribuição seminal de Lucas (1988) para a literatura de crescimento endógeno, esta variável vem sendo esmiuçada em diversos trabalhos teóricos e empíricos, os quais procuram compreender a magnitude do impacto de investimentos em capital humano sobre o crescimento econômico de países e regiões, bem como seus potenciais canais de transmissão. Cabe ressaltar que o modelo de crescimento proposto por Lucas (1988) já considerava que o capital humano produziria efeitos positivos tanto sobre a produtividade agregada da economia quanto sobre ambos os tipos de insumos produtivos, capital físico e trabalho, contrapondo os retornos decrescentes destes fatores de produção e permitindo maior crescimento de longo prazo.

Trabalhos mais recentes apontam que níveis educacionais elevados não apenas seriam capazer de amplificar o impacto dos insumos acumuláveis sobre a produção, como também determinariam maiores taxas de inovações tecnológicas nos países produtores de tecnologia, ao mesmo tempo que facilitam a absorção desta por países que a copiam.Para detalhada revisão desta literatura detalhada, ver Loayza, et al. (2005)

Contudo, não existe ainda consenso na literatura no que concerne à magnitude do impacto da educação sobre o crescimento de longo prazo. Conforme reportam Bils and Klenow (2000),

muitos trabalhos encontraram correlação positiva entre níveis iniciais de educação (taxa de escolaridade) e taxa de crescimento subsequente do PIB per capita entre os países.Entre eles, Robert J. Barro (1991), Jess Benhabib and Mark M. Spiegel (1994), Barro and Xavier Sala-i-Martin (1995), Sala-i-Martin (1997) Visando elucidar esta relação, os autores propõem um modelo de vida finita no qual o capital humano dos indivíduos pode aumentar com a escolaridade e contribuir, portanto, para a taxa de crescimento de um país.

A conclusão a que chegam é intrigante: o impacto da educação no crescimento consegue explicar provavelmente menos que um terço da relação cross-country, e possivelmente muito menos do que um terço. A alta correlação entre escolaridade e crescimento econômico subsequente, portanto, não se deveria ao impacto da escolaridade no crescimento, podendo ser consequência tanto de causalidade reversa quanto da omissão de importantes variáveis que se relacionariam simultaneamente com as taxas de escolaridade no início do período analisado e com as taxas de crescimento do produto no mesmo período, tais como garantias de direitos de propriedade e abertura comercial.

As medidas para educação mais comumente empregadas na literatura são taxas de matrícula - no ensino primário, secundário e superior - ou anos médios de escolaridade. Barro (1991) encontrou correlação positiva entre crescimento no PIB real per capita no período 1960-1985 e taxas de matrícula em 1960 nos ensino primário e secundário, consideradas separadamente. Por sua vez, Bils and Klenow (2000) construíram um variável agregada para educação, na qual escolaridade é igual a seis vezes a taxa de matrícula no ensino primario mais seis vezes a a taxa de matrícula no ensino secundário mais quatro vezes a taxa de matrícula no ensino superior, correspondendo às durações de cada nível educacional de acordo com convenções do Banco Mundial. Regredindo a taxa crescimento per capita média entre 1960-1990 apenas nesta variável agregada de educação, os autores concluem que o crescimento nas taxas de matrícula equivalente a um ano adicional de escolaridade implica em um crescimento anual 0,30% maior no período considerado.

No entanto, ao adicionarem à regressão a medida para educação adotada em Barro and Sala-i-Martin (1995), "anos médios de escolaridade da população em idade ativa", estas conclusões puderam ser refinadas. Apesar de o crescimento continuar a ser altamente correlacionado com as taxas de matrícula (0,476%), o coeficiente da variável anos médios de escolaridade, quando condicionado àquela medida, é negativo e marginalmente significante. Isso equivale a dizer que, condicional às taxas de matrícula medidas em 1960, taxas de matrículas passadas não produzem qualquer efeito positivo no crescimento. Os autores consideram que este é um indício forte de que as relações causais entre as taxas de matrícula em 1960 e o crescimento econômico se devam apenas à dinâmica transicional de crescimento do capital humano ou da tecnologia, e não a um impacto de equilíbrio estacionário no crescimento.

A medida que escolhemos para avaliar o impacto da educação ao longo dos anos e entre países é aquela responsável por tais polêmicas conclusões: anos médios de escolaridade da população em idade ativa. Embora reconheçamos que ela não é à prova de críticas, ainda não é viável incorporar medidas mais adequadas para capital humano, como as que levam em consideração características cognitivas baseadas em resultados de testes internacionais de disciplinas-chaveAverage test scores in math and science - como os desenvolvidos pelo Programme for International Student Assessment (PISA) - em análises derivadas de dados em painel, devido à escassez de informações na dimensão das séries temporais.

Uma dessas medidas alternativas para capital humano foi proposta por Hanushek and Woessman (2012). Perante à questão colocada por Pritchett, L. (2006) e Bils e Klenow (2000), os autores defendem a tese de que, na verdade, os resultados empíricos vão de encontro à forte relação entre educação e taxa de crescimento proposta pelos modelos devido à medida para capital humano adotada não ser válida. Eles mostram que, a partir da medida de educação por eles desenvolvida, à qual denominam cognitive skills, é possível reestabelecer, ao menos em regressões de crescimento cross-country, uma relação robusta entre educação e crescimento do

GDP.

No entanto, conforme os próprios autores ressaltam, o fato de as medidas propostas serem construídas a partir de resultados de testes aplicados a estudantes que continuam na escola - e não a participantes da força de trabalho - impossibilita a utilização delas em estimações baseadas em dados em painel. Essa impossibilidade advém de três principais dificuldades. Em primeiro lugar, a característica esporádica da aplicação dos testes cognitivos, ou seja, da medida dos cognitive skills, comprometeria substancialmente a dimensão de séries temporais. Em segundo, esta medida demandaria a adoção de hipóteses muito fortes acerca do mapeamento ao longo do tempo dos skills de indivíduos ainda com idade escolar em skills de trabalhadores. Por fim, os autores reportam que a maior parte da variância no crescimento e nos resultados dos testes ocorre entre países, e não ao longo do tempo em cada um dos países (73% vs. 27%), de maneira que a análise em dados em painel não conseguiria lidar com importantes questões impostas à estimação.

Desenvolvimento Financeiro O terceiro subgrupo de política estrutural é o que chamaremos de “desenvolvimento financeiro”. Até meados da década de 1980, a importância do sistema financeiro para o crescimento econômico havia sido negligenciada por boa parte dos autores da área. Enquanto alguns, como Joan Robinson (1952), acreditavam que, na verdade, o crescimento econômico é que demandava novos arranjos financeiros, sendo estes prontamente atendidos pelo desenvolvimento de um sistema financeiro local, outros, como Lucas (1988), consideravam exagerada a importância concedida por alguns estudos ao suposto impacto do sistema financeiro sobre o crescimento econômico (LEVINE, 1997).

Embora ainda não haja consenso acerca da magnitude do impacto desta variável ou da importância relativa de seus canais de transmissão, já consta na literatura um volume suficientemente grande de contribuições teóricas e de evidências empíricasEstudos no nível da firma, da indústria e comparações cross-country chegam à mesma conclusão. Levine (1997) reporta algumas contribuições fundamentais desta literatura. que corroboram a relação positiva entre o desenvolvimento das instituições financeiras de um país e suas subsequentes taxas de crescimento econômico.

Apenas em economias em que exista assimetria informacional e custos de transação haverá necessidade do surgimento de mercados e instituições financeiras. Isto é, sistemas financeiros surgem visando a reduzir fricções econômicas em um ambiente incerto de negócios. Os tipos específicos de fricções existentes irão então moldar os mercados financeiros e seus intermediários, os quais serão responsáveis por facilitar a divesificação do risco e a troca de bens e serviços, por alocar recursos, por monitorar gerentes e estabelecer controle corporativo e por mobilizar poupanças. Cada uma dessas funções de um desenvolvido sistema financeiro, por sua vez, afetará o crescimento econômico por meio de dois canais principais: acumulação de capital e inovação tecnológica (LEVINE, 1997).

Como medida de desenvolvimento financeiro, optamos pela participação do crédito doméstico para o setor privado no PIB de cada país (Beck, T., A. Demirguc-Kunt, and R. Levine (1999)). O crédito doméstico para o setor privado engloba todos os recursos financeiros que são fornecidos por corporações financeiras ao setor privado. Incluem-se na definição de corporações financeiras: autoridades monetárias, bancos de depósito e outras corporações financeiras, tais como empresas financeiras e de leasing, emprestadores, seguradoras, fundos de pensão e empresas de câmbio, quando há disponibilidade de dados.

A escolha por esta variável para representar os diferentes níveis de desenvolvimento financeiro dos países deve-se, primeiramente, à relativa abundância de suas observações frente a medidas alternativas, fazendo com que tenha sido priorizada em estudos recentes baseados em painel de dados (como em Calderón and Servén (2010)). Além disso, a opção por restringir o crédito doméstico ao setor privado justifica-se pelo fato de agentes privados terem incentivos fortes e claros para atuarem no mercado de forma eficiente (ver Loayza, et al. (2005)).

Abertura Comercial A quarta área de política estrutural considerada neste trabalho é a "abertura comercial". A relação positiva entre maiores graus de liberalização do comércio de bens e serviços e crescimento econômico vem sendo estabelecida a partir de extensa evidência empírica. Conforme reportam Loayza, et al. (2005), o comércio internacional consegue afetar o crescimento econômico dos países e regiões por intermédio de cinco canais.

Primeiramente, ao permitir que os países identifiquem suas áreas de maior vantagem comparativa e a elas dediquem maior atenção e esforços, a abertura comercial induz níveis mais elevados de especialização e, consequentemente, promove aumento da produtividade total dos fatores nas economias engajadas em trocas internacionais. Em segundo lugar, a produtividade também é impulsionada devido à possibilidade de obtenção de maiores economias de escala, a partir da ampliação de mercados potenciais para a produção das firmas domésticas. Em terceiro, ao propiciar interações entre firmas e mercados em nível global, tanto inovações tecnológicas quanto práticas gerenciais eficientes podem ser difundidas internacionalmente. Em quarto, a abertura comercial automaticamente desestimula práticas anticompetitivas, possivelmente habituais entre firmas de economias relativamente mais fechadas. Por fim, o livre-mercado desincentiva atividades empresariais geralmente improdutivas, como as de rent-seeking.

Uma medida para abertura comercial vastamente empregada em estudos de crescimento econômico é o "volume de comércio", expresso pela razão entre a soma das exportações e importações de bens e serviços e o PIB de cada país (ver Calderón and Servén (2010)). Contudo, esta não é uma medida apropriada para análises comparativas entre países, uma vez que estaríamos atribuindo erronamente a políticas comerciais o que seria, na verdade, inerente a características estruturais desses países. Países pequenos, por exemplo, são mais dependentes do comércio internacional do que grandes nações; países exportadores de petróleo geralmente possuem altíssimos volumes de comércio, ao mesmo tempo que impõem altas tarifas de importação; e países sem fronteira litorânea enfrentam maiores custos de transporte, o que implica, via de regra, em menores volumes relativos de comércio (Loayza, et al. (2005)).

As evidências trazidas por Pritchett (1996) deixam claro o desafio imposto pela escolha de uma medida para abertura comercial adequada a uma abordagem empírica. O autor mostrou, por meio de um estudo cross-country, que medidas alternativas de orientação da política comercial comumente empregadas pela literatura são não-correlacionadas tanto individual quanto coletivamente.Foram analisadas quatro métricas: (a) parcela de comércio (ou importação) no PIB, ajustada para características estrututais dos países ou dotação de fatores; (b) a tatifa média e razão de cobertura das barreiras não-tarifárias; (c) medidas do desvio entre padrão de comércio observado nos países e o previsto por um modelo de vantagens comparativas baseadas nos recursos de cada país; (d) uma medida de distorção de preços. Devemos, portanto, ser bastante cautelosos ao interpretar o impacto de cada uma dessas métricas sobre o crescimento econômico, na medida em que cada uma delas potencialmente reflete dimensões diferentes do comércio internacional e, portanto, exerce efeito diverso sobre o crescimento dos países.

Por todo o exposto, neste trabalho, optamos por medir abertura comercial por meio do "volume de comércio ajustado pela estrutura" de um país, métrica esta similar a uma das analisadas por Pritchett (1996), e utilizada também por Loayza, et al. (2005). O volume do comércio de cada um dos países é, portanto, ajustado pelo seu tamanho (área e população), e pelas características de ele ser litorâneo ou não e de ser exportador de petróleo ou não.

Fardo Governamental O último subgrupo de políticas estruturais de que trataremos referese ao fardo que o governo é capaz de impor às atividades produtivas desempenhadas pelo setor privado. Muito embora haja espaço para que Estado atue positivamente na dinâmica econômica dos países - seja por meio do fornecimento de serviços de saúde, infraestrutura, educação, etc -, sua intervenção pode significar também um grande "peso" aos agentes privados.

Não raro é possivel observar não apenas cobranças excessivas e irresponsáveis de impostos, mas também a receita obtida com a arrecadação ser subsequentemente empregada na

manutenção de programas sociais ineficientes e da burocracia estatal.Sobre efeitos de diferentes reformas e sistemas tributários sobre o crescimento econômico, ver Engen and Skinner (1996) No mais, a intervenção desregulada do Estado em atividades que deveriam ser desempenhadas pelo setor privado é capaz de promover distorções nos incentivos de mercado, gerando custos adicionais em termos de eficiência para a economia (Loayza, et al. (2005)).

A medida que adotamos como proxy de fardo governamental é a razão entre o consumo final do governo e o PIB. Esta variável de consumo abarca todos os gastos correntes do governo com compras de bens e serviços - inclusive com a folha de pagamentos de seus empregados - e a maior parcela de gastos com defesa nacional e segurança.Mas exclui gastos militares, que são um componente da formação de capital do governo. Tal escolha justifica-se pelo fato de boa parte dos gastos governamentais com consumo via de regra não se destinar a funções sociais, como educação e saúde. Cabe ressaltar que diversos outros estudos em crescimento econômico empregam esta mesma métrica, tais como Barro and Sala-i-Martin (1995), Loayza, et al. (2005), Calderón and Servén (2008) e Calderón and Servén (2010).

Políticas de Estabilização

Conforme foi brevemente descrito na subseção 2.2.3, ao tratarmos da variável para reversão cíclica - e ficará claro no capítulo 3 -, as estimações e projeções realizadas neste trabalho utilizam médias de 5 anos. Apesar de termos agrupado observações em médias e controlado para o hiato do produto do início de cada período considerado, existe ainda a possibilidade de não termos conseguido extrair completamente o componente cíclico dos dados da amostra, como seria adequado a uma análise de taxas de crescimento.

Esse obstáculo sugere que devamos adicionar controles adicionais para movimentos cíclicos, refletindo períodos de recessão, recuperação e crise. Os períodos relativamente curtos de estimação trazem a necessidade adicional de considerarmos os efeitos potenciais sobre a taxa de crescimento que políticas de estabilização trazem a reboque.

A estabilidade macroeconômica é considerada condição necessária, ainda que não-suficiente, para o crescimento econômico sustentado. Vasta evidência internacional sugere que as taxas de crescimento se relacionam negativamente com taxa de inflação e positivamente com bom desempenho fiscal e política cambial não-distorciva. Não há dúvidas também acerca da capacidade de a estabilidade macroeconômica produzir efeitos positivos tanto a curto quanto a longo prazo. Quando há a redução dos níveis de incerteza percebidos pelos agentes, o ambiente econômico se torna mais propício a investimentos e a fuga de capitais diminui. Ademais, quando à incerteza estão associadas alta inflação ou instabilidade fiscal, pode haver redução tanto dos níveis quanto das taxas de crescimento da produtividade. (Fischer (1993)).

Ao incluirmos proxies para políticas de estabilização, damos mais um passo em direção à estimação de coeficientes para variáveis de reversão cíclica e de políticas estruturais não-viesados. Esses regressores também contribuem significativamente para melhorar o fit da estimação e o poder de previsão das projeções. (Loayza, et al. (2005)).

Dividiremos as políticas macroeconômicas de estabilização em 2 subgrupos: (ausência de) estabilidade de preços e (ausência de) estabilidade do produto.

Ausência de estabilidade de preços De acordo com Fischer (1993), o ambiente macroeconômico pode ser considerado estável quando cinco critérios são observados: (i) a inflação é baixa e previsível, (ii) as taxas reais de juros são apropriadas. (iii) a política fiscal é estável e sustentável, (iv) a taxa real de câmbio é competitiva e previsível e (v) a situação do balanço de pagamentos é percebida como viável. Como o próprio autor destaca, esta definição vai além dos instrumentos de política monetária ao incluir critérios para a definição de níveis a serem

atingidos por variáveis de política econômica. Dos cinco critérios listados, no entanto, apenas inflação baixa e estável pode ser rapidamente quantificada.

A medida que adotamos para a ausência de estabilidade de preços é, portanto, a taxa de inflação média observada em cada país, em cada um dos períodos analisados. A inflação média é considerada um bom indicador para a qualidade das políticas fiscais e monetárias de uma economia, e é correlacionada com outros indicadores clássicos de ausência de estabilidade macroeconômica, como déficits fiscais e prêmio no mercado negro para moeda estrangeira (Loayza, et al. (2005)).

Em outras palavras, a taxa de inflação pode ser considerada um excelente indicador da capacidade geral do governo em administrar a economia. Não existem bons argumentos para manter taxas muito altas de inflação, de maneira que se um governos as produz, naturalmente ele perdeu o controle. Agentes econômicos, portanto, esperam que haja um ataque a inflação, quando ela se mantém em níveis médios ou altos por um determinado período de tempo (Fischer, 1993).

Ausência de estabilidade do produto Seguindo Loayza, et al. (2005), a medida que utlilizaremos para representar a ausência de estabilidade do produto será a volatilidade cíclica do PIB, calculada como o desvio-padrão do hiato do produto para cada país, em cada um dos períodos analisados.

Condições Externas

Não apenas o ambiente econômico doméstico influencia a dinâmica das atividades produtivas dos países e regiões. As condições externas também ajudam a refrear ou impulsionar o crescimento econômico dos mesmos, ora impondo limitações, ora ampliando as possibilidades de expansão dos mercados. No mais, mudanças no quadro externo podem tanto afetar de forma horizontal inúmeros países, quanto se manterem restritas a determinado grupo que compartilhe de características semelhantes, estruturais ou comerciais. Os efeitos de crises internacionais podem perdurar por vários anos, ou serem rapidamente dissipados por meio de medidas contra-cíclicas.

Como podemos observar, choques externos podem ser extremamente heterogêneos e, consequentemente, provocar desdobramentos também de diferentes naturezas e magnitudes. Isso posto, consideraremos duas categorias de variáveis, as quais deverão refletir diferentes dimensões de tais desdobramentos. São elas: "choques nos termos de troca" e "condições globais", representando, respectivamente, choques que afetam de forma individual os países da amostra e choques que afetam igualmente todos os países.

Choques nos Termos de Troca Ao adicionarmos uma medida para choques nos termos de troca na regressão de crescimento, buscamos auferir o impacto sobre o mesmo de mudanças no valor das exportações (e, portanto, na demanda internacional por determinado produto) e das importações (como custos de insumos produtivos) de bens e serviços em cada país da amostra. Como queremos analisar choques - i.e., alterações nos termos de troca - a métrica que utilizaremos será uma log-diferença dos termos de troca (taxa de crescimento dos termos de troca).

Variações nos preços das commodities se refletem primariamente em mudanças nos termos de troca, o que explica, portanto, a importância desta variável para diversas interpretações que poderão ser feitas a partir do resultado de nosso exercício econométrico.

Condições Globais As dummies de tempo, por sua vez, captam as condições globais da economia mundial em cada período específico, ou seja, recessões, booms, alterações na alocação e no custo dos fluxos internacionais de capital e mudanças tecnológicas (Loayza, et al. (2005)).

3.3 Estimação e Resultados

3.3.1 Amostra e Estatísticas Descritivas

Conforme indicamos nas seções anteriores, neste trabalho buscaremos avaliar empiricamente a contribuição individualizada de cinco grupos de variáveis para o crescimento econômico dos países, por meio de um painel dinâmico. A amostra utilizada na estimação proposta contém observações para países pertencentes às principais regiões do mundo, de acordo com a disponibilidade de dados.

Uma vez que esta categoria de análise deve aludir a relações de longo prazo entre as variáveis que, por hipótese, afetam o crescimento econômico, trabalharemos com médias de cinco anos, como forma de remover componentes meramente cíclicos das séries. A dimensão "time-series" do painel abrange o intervalo de quarenta e cinco anos que se estende desde 1966 até 2010, e é composta, portanto, por nove períodos de (médias) de cinco anos (1966-1970, 1971-1975, 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, 2006-2010). Contudo, devido ao fato de a observação inicial de cada país se destinar apenas à instrumentação, o primeiro período da regressão se refere aos anos 1971-1975.

Por sua vez, pra delimitação da dimensão "cross-country" fora, primeiramente, excluídos da amostra países considerados "economias muito pequenas", quais sejam, aqueles em que a população era inferior a um milhão de habitantes em 2005. Incluir tais economias traria algumas complicações adicionais à variável de infraestrutura, tais como indivisibildades, conforme destacaram Calderón and Sérven (2010). Do conjunto remanescente de países, foram excluídos todos aqueles que não possuíam no mínimo três observações (ou seja, três períodos com informação completa), necessárias para que o método de variáveis instrumentais pudesse ser implementado.

Definidas as categorias "time-series" e "cross-country" do painel, a amostra que nele se baseia e que representa nosso objeto de investigação é constituída por dados de 83 países, dos quais 18 são da América Latina e Caribe, totalizando 526 observações, os quais encontram-se listados na Tabela 2:

Table 3.2: Regiões e Países

Region	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	North America	South Asia	Sub Saharian Africa	
Country	Australia	Belgium	Argentina	Egypt	Canada	Bangladesh	Benin	Niger
	China	Denmark	Bolivia	Israel	United States	India	Botswana	Rwanda
	Hong Kong	Finland	Brazil	Jordan		Pakistan	Burundi	Senegal
	Indonesia	France	Chile	Morocco		Sri Lanka	Cameroon	South Africa
	Japan	Germany	Colombia	Tunisia			Central African Republic	Sudan
	Malaysia	Greece	Costa Rica				Congo, Dem. Rep.	Tanzania
	New Zealand	Hungary	Dominican Rep.				Congo, Republic of	Togo
	Philippines	Ireland	Ecuador				Cote d'Ivoire	Uganda
	Singapore	Italy	El Salvador				Gabon	Zambia
	Thailand	Netherlands	Guatemala				Gambia, The	Zimbabwe
		Norway	Honduras				Ghana	
		Poland	Mexico				Kenya	
		Spain	Panama				Lesotho	
		Sweden	Paraguay				Malawi	
		Turkey	Peru				Mali	
		United Kingdom	Trinidad Tobago				Mauritania	
			Uruguay				Mauritius	
			Venezuela				Mozambique	

A tabela 3 apresenta as estatísticas univariadas para os dados da amostra, isto é, a média, desvio-padrão, mínimo e máximo para cada uma das variáveis consideradas.

Table 3.3: Estatísticas Descritivas Univariadas

Estatísticas Univariadas				
Variável	Média	Desv. Padrão	Min.	Max.
taxa de crescimento do PIB per capita	0,0566	0,0870	-0,3821	0,4820
PIB per capita inicial (log)	8,2250	1,2898	5,3887	10,9455
hiato do produto inicial (log)	0,0155	0,1662	-0,4337	1,5776
anos médios de escolaridade (log)	1,6839	0,7005	-1,2379	2,9818
crédito doméstico/PIB (log)	3,3587	0,9658	-0,1783	5,9852
volume de comércio ajustado pela estrutura (log)	0,0339	0,4663	-1,4650	1,4559
consumo final do governo/PIB (log)	2,6818	0,4305	1,3526	4,2485
linhas telefônicas/1000hab (log)	3,4573	2,0623	-1,6134	6,9878
inflação log((1+dp)*100)	6,7538	1,1014	1,3184	13,1576
desvio-padrão do hiato do produto	0,0249	0,0257	0,0001	0,2729
taxa de crescimento dos termos de troca	-0,0275	0,2119	-1,7058	1,1242

A variável dependente da regressão, taxa de crescimento do PIB per capita, apresenta desvio-padrão de aproximadamente 9 pontos percentuais. As mais altas dispersões da amostra aparecem nas variáveis "linhas telefônicas/1000hab" (206%), "PIB per capita inicial" (129%) e "inflação" (110%).

As distribuições de algumas variáveis explicativas de política estrutural, como "anos médios de escolaridade", "linhas de telefone" e "crédito doméstico para o setor privado" são assimétricas negativas (apresentam frequências mais altas para os maiores valores e as caudas são mais longas à esquerda), refletindo a presença na amostra de países com baixíssimo desempenho nestas áreas.

Por sua vez, a distribuição das variáveis "hiato do produto per capita inicial", "consumo do governo" e "desvio-padrão do hiato do produto" são assimétricas positivas leptocúrticas,

isto é, apresentam frequência mais alta para valores menores e a cauda à direita é mais longa, possivelmente devido a existência de períodos de instabilidade da economia de alguns países da amostra.

Por fim, as variáveis remanescentes, tal como a própria variável dependente, "taxa de crescimento do PIB per capita" e as explicativas "PIB per capita inicial", "volume de comércio ajustado pela estrutura", "taxa de inflação" e "taxa de crescimento dos termos de troca" apresentam distribuição simétrica, ainda que na presença de outliers.

Em seu turno, a tabela 4 a seguir traz as correlações entre pares de variáveis.

Table 3.4: Correlações

Correlações										
Variável	taxa de crescimento do PIB per capita	PIB per capita inicial (log)	hiato do produto inicial (log)	anos médios de escolaridade (log)	crédito doméstico/PIB (log)	volume de comércio ajustado (log)	consumo final do governo /PIB (log)	linhas telefônicas/ 1000hab (log)	inflação	desvio-padrão do hiato do produto
taxa de crescimento do PIB per capita	1,00	0,07	0,05	0,15	0,20	0,17	-0,06	0,17	-0,13	-0,02
PIB per capita inicial (log)		1,00	0,04	0,73	0,70	0,20	0,36	0,91	-0,21	-0,13
hiato do produto inicial (log)			1,00	0,10	0,00	-0,14	-0,04	0,07	0,14	0,05
anos médios de escolaridade (log)				1,00	0,57	0,29	0,25	0,79	-0,10	-0,11
crédito doméstico/PIB (log)					1,00	0,35	0,33	0,75	-0,35	-0,11
volume de comércio ajustado (log)						1,00	0,26	0,25	-0,18	-0,01
consumo final do governo/PIB (log)							1,00	0,34	-0,14	-0,04
linhas telefônicas/1000hab (log)								1,00	-0,23	-0,18
inflação log((1+dp)*100)									1,00	0,13
desvio-padrão do hiato do produto										1,00
taxa de crescimento dos termos de troca										

Algumas considerações importantes podem ser feitas. Em primeiro lugar, variáveis escolhidas para indicar desenvolvimento econômico (tais como anos médios de escolaridade, crédito doméstico/PIB, volume de comércio ajustado e linhas telefônicas/1000hab) são todas positivamente correlacionadas entre si e negativamente correlacionadas coma as duas variáveis que denotam políticas de estabilização, as quais refletem instabilidade e crise. Estas por sua vez, exibem correlação positiva entre si (0,13).

Em segundo lugar, a correlação entre a taxa de crescimento do PIB per capita e o nível do PIB per capita inicial é positiva (0,07), sugerindo o resultado contraintuitivo de haver divergência absoluta no grupo de países da amostra.

Por fim, cabe ressaltar que os sinais dos coeficientes de correlação entre a taxa de crescimento do PIB per capita e as variáveis explicativas propostas são os esperados, exceto para a relação com o hiato do produto inicial, que é positiva, embora apresente magnitude bastante reduzida.

3.3.2 Metodologia de Estimação

Modelo Empírico de Crescimento

A equação de regressão de crescimento econômico que será estimada assume o seguinte formato:

$$y_{i,t} - y_{i,t-1} = \rho y_{i,t-1} + \beta' X_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t} \tag{3.1}$$

para $i = 1, ..., N$ e $t = 2, ..., T$.
onde y representa o log do PIB per capita, X é o conjunto de variáveis explicativas, que supostamente produzem efeitos sobre o crescimento econômico[1] e $\varepsilon_{i,t}$ é o resíduo da regressão. Os subscritos i e t denotam, respectivamente, países e períodos de tempo, tais que $i \in \{1, 2, ..., N\}$ e $t \in \{2, ..., T\}$. Dessa forma, o lado esquerdo da equação, $y_{i,t} - y_{i,t-1}$, representa a taxa de crescimento do PIB per capita entre os períodos $t-1$ e t e o primeiro termo do lado direito, $\rho y_{i,t-1}$, controla para os efeitos da convergência transicional. Cada μ_t refere-se a um choque não-observável que afeta todos os países de forma homogênea no período t (period-specific effects) e η_i refere-se a efeitos não-observáveis específicos a cada país i (unobserved country-specific effects).

Posto de outra forma, μ_t permite que controlemos para eventos internacionais, o quais podem se alterar de acordo com o período estudado, e que afetam, sem distinção, o crescimento econômico de todos os países. Já η_i refere-se a características específicas a cada um dos N países da amostra, que não podem ser observadas e que, portanto, são potencialmente correlacionadas com as variáveis explicativas presentes.

Para conseguirmos estimar adequadamente a regressão de crescimento proposta, precisaremos inicialmente contornar alguns obstáculos impostos pela presença das duas modalidades de efeito não-observáveis. Além disso, existe ainda o desafio imposto pela possibilidade, que não deve ser descartada, de as variáveis explicativas serem conjuntamente endógenas com a taxa de crescimento econômico, sendo, portanto, necessário lançar mão de instrumentos para evitar a obtenção de estimadores viesados devido à simultaneidade e causalidade reversa (ver Loyaza, et al. (2005)).

Adicionalmente, erros de mensuração e variáveis omitidas, também fontes de endogeneidade, são dificuldades tipicamente atribuídas à estimação de modelos de crescimento. Por exemplo, o "nível inicial de eficiência" é uma variável que deveria ser incluída em uma regressão de covergência condicional mas é, no entanto, não-observável. Como essa variável omitida será correlacionada com um dos regressores, o "nível inicial de produto", os estimadores de mínimos quadrados serão viesados. (Bond et al. (2001)).

Metodologia Econométrica

Estimação do Modelo Empírico de Crescimento Conforme esclareceremos nesta seção, os estimadores de métodos de momentos generalizados propostos por Arellano e Bover (1995) e Blundell e

[1] Incluindo o hiato do produto no início do período, $y_{i,t-1} - y^T_{i,t-1}$, onde $y^T_{i,t-1}$representa o componente de tendência da série.

Bond (1997) - conhecidos como estimadores GMM sistêmicos - são capazes de lidar de maneira apropriada com as dificuldades trazidas pela estimação de modelos empíricos de crescimento.

Primeiramente, reescreveremos a equação (1) da seguinte forma:

$$y_{i,t} = \alpha y_{i,t-1} + \beta' X_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t} \tag{3.2}$$

, onde $\alpha = \rho + 1$.

Na seção 2.2.5, incluímos "dummies de tempo" no conjunto de variáveis explicativas no modelo, sob a forma de proxies para certas condições externas que podem impactar diretamente sobre o crescimento econômico. Exatamente como prevê a inclusão de μ_t no modelo, essas dummies conseguem captar alterações no ambiente econômico internacional que afetem horizontalmente todos os países da amostra. Sendo assim, a equação (2) pode ser reescrita omitindo-se a variável μ_t, isto é:

$$y_{i,t} = \alpha y_{i,t-1} + \beta' X_{i,t} + \eta_i + \varepsilon_{i,t} \tag{3.3}$$

O próximo passo refere-se ao tratamento concedido ao componente não-observável específico a cada país, η_i. Uma variável não-observável e que não se altera com o passar do tempo é chamada de "efeito não-observável" em análises de dados em painel. No caso do estudo em tela, esta variável capta características instrínsecas de cada país, que não mudam ao longo dos períodos considerados na amostra, e que podem influenciar o crescimento econômico destes países.

Essa heterogeneidade não-observável pode ser tratada como um "efeito fixo" ou um "efeito aleatório". Tratar η_i como um efeito aleatório equivale a assumir correção nula entre as variáveis explicativas observáveis do modelo e o efeito não-observável, isto é, $Cov(x_{it}, \eta_i) = 0$, $t = 1, 2, ..., T$.[2] Já na abordagem que considera η_i um efeito fixo, permite-se que haja dependência arbitrária entre as variáveis explicativas e o efeito não-observável. Contudo, as estimações de efeitos fixos ou efeitos aleatórios assumem exogeneidade estrita dos instrumentos condicional ao efeito não-observável. No mais, a estimação de efeitos aleatórios se apóia na hipótese adicional de que as variáveis instrumentais possuem correlação nula com o efeito não-observável (Wooldridge, 2010).

Em modelos dinâmicos com heterogeneidade não-observável, como o de crescimento econômico que adotamos, um dos regressores é nada mais do que um lag da variável dependente (ou lagged dependent variable model). Dessa forma, por construção, a hipótese de exogeneidade estrita não se sustenta e, portanto, outro método deve ser adotado para a estimação dos coeficientes da regressão na presença de efeitos não-observáveis.

Estimador GMM em Diferenças Observando as singularidades impostas pelos modelos dinâmicos de dados em painel, Holtz-Eakin, Newey e Rosen (1988) e Arellano e Bond (1991) desenvolveram estimadores de métodos de momentos generalizados em primeiras diferenças. Por sua vez, a aplicação seminal deste ferramental para o estudo do crescimento econômico foi proposta por Caselli, Esquivel and Lefort (1996).

Em linhas gerais, o procedimento proposto consiste em (i) escrever a equação de regressão no formato de um modelo de dados em painel, (ii) remover o efeitos não-observáveis específicos a cada país, a partir das primeiras diferenças da equação de regressão, (iii) usar como instrumentos para as variáveis explicativas (incluindo, portanto, o lag do produto, chamada de variável lagged dependent), nas equações em primeiras diferenças, os lags (de dois períodos ou mais) dos níveis das séries, assumindo a hipótese de que os resíduos das equações em nível não são serialmente correlacionados (Bond et al. (2001)).

Ou seja, além das hipóteses convencionais,

$$E(\eta_i) = 0; \quad E(\varepsilon_{i,t}) = 0; \quad E(\varepsilon_{i,t}\eta_i) = 0 \tag{3.4}$$

para $i = 1, ..., N$ e $t = 2, ..., T$,
assume-se

$$E(\varepsilon_{i,t}\varepsilon_{i,s}) = 0 \tag{3.5}$$

[2] Para que inferências estatísticas sejam justificáveis, é necessária uma hipótese de independência condicional ainda mais forte: $E(\eta_i | x_{i1}, ..., x_{iT}) = E(\eta_i)$

para $i = 1, ..., N$ e $s \neq t$.

Por fim, é feita também a hipótese de que as condições iniciais são pré-determinadas:
$E(y_{i,1}\varepsilon_{i,t}) = 0 \quad E(X_{i,1}\varepsilon_{i,t}) = 0$

$$ \tag{3.6} $$

para $i = 1, ..., N$ e $t = 2, ..., T$,

As condições (4), (5) e (6) implicam em condições de momento que são suficientes para estimar os parâmetros de interesse.

Tomando as primeiras diferenças da equação (3), temos:

$$(y_{i,t} - y_{i,t-1}) = \alpha (y_{i,t-1} - y_{i,t-2}) + \beta' (X_{i,t} - X_{i,t-1}) + (\varepsilon_{i,t} - \varepsilon_{i,t-1}) \tag{3.7}$$

Ou seja,

$$\triangle y_{i,t} = \alpha \triangle y_{i,t-1} + \beta' \triangle X_{i,t} + \triangle \varepsilon_{i,t} \tag{3.8}$$

A utilização de variáveis instrumentais se justifica tanto pela endogeneidade das variáveis explicativas quanto pelo fato de o novo termo de erro, $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$, por construção, ser correlacionado com a variável lagged dependent, $(y_{i,t-1} - y_{i,t-2})$, conforme fica claro na equação (4).

Os instrumentos propostos para a equação em diferenças são justamente os lags dos níveis das variáveis explicativas e da variável lagged dependent. Dessa forma, apesar de relaxar a hipótese de exogeneidade estrita, o método proposto não permite que as variáveis explicativas sejam totalmente endógenas, uma vez que só há possibilidade de correlação diferente de zero entre o termo de erro e valores correntes e futuros das variáveis explicativas (Loyaza et al. (2005)).

Portanto, sob a hipótese adicional de que as variáveis explicativas são fracamente exógenas (ou seja, não são correlacionadas com valores futuros do termo de erro), as condições de momento utilizadas pelo estimador GMM de painel dinâmico em primeiras diferenças (o chamado "estimador em diferenças") são dadas por:

$$E\left[y_{i,t-s}\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\right] = 0 \tag{3.9}$$

$$E\left[X_{i,t-s}\left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\right] = 0 \tag{3.10}$$

para $s \geq 2$ e $t = 3, ..., T$.

Bond et al. (2001) aponta três motivos pelos quais este procedimento de estimação é vantajoso para o estudo do crescimento econômico, se comparado a regressões cross-section e a outros métodos de estimação para modelos de painel dinâmico. Em primeiro lugar, os estimadores não serão mais viesados por conta da omissão de variáveis que são constantes no tempo (efeitos fixos ou variáveis não-observáveis específicas a cada país). Além disso, por lançar mão de instrumentos, os parâmetros estimados são consistentes mesmo em modelos nos quais existem variáveis explicativas endógenas. Por fim, mesmo na presença de erro de medida, a utilização de variáveis instrumentais favorece uma estimação consistente dos parâmetros de interesse.

Contudo, a partir da contribuição de Blundell e Bond (1998), ficou estabelecido que se o valor do parâmetro autorregressivo for moderadamente alto - isto é, no caso de as séries de tempo serem persistentes - e o número de observações das séries de tempo for moderadamente pequeno, o estimador proposto por Arellano e Bond (1991) para modelos de painel dinâmico apresentará viés de amostras grandes finitas e baixa precisão nos estudos de simulação. O desempenho decepcionante desses estimadores ocorre devido aos instrumentos escolhidos para as equações em diferenças - os lags dos níveis das séries - serem instrumentos fracos sob tais condições.

Essa ressalva é particularmente importante quando estimamos parâmetros das equações de crescimento econômico. Se, por um lado, as séries de produto são altamente persistentes, por outro, conforme já explicitamos, a maior parte dos estudos empíricos de crescimento conta com um número reduzido de períodos de tempo, uma vez que, para se evitar a influência de movimentos cíclicos na análise, trabalha-se com médias de cinco anos (Bond et al. (2001)).

Estimador GMM Sistêmico Como resposta esta insuficiência do estimador linear em diferenças, Arellano e Bover (1995) e Blundell e Bond (1998) propuseram um estimador GMM-IV sistêmico. Em linhas gerais, o método consiste em se estimar um sistema formado tanto por equações em primeiras diferenças quanto em níveis, no qual os instrumentos para as equações em diferenças continuam a ser os do procedimento do estimador em diferenças. Já para as "novas" equações em níveis, os instrumentos propostos são os lags das primeiras diferenças das séries.

A validade desses instrumentos, por sua vez, dependerá de uma hipótese adicional, que recairá nas condições iniciais. Bond et al (2001) mostra que essas restrições são consistentes com as abordagens padrão de crescimento, e recomendam a adoção deste método de estimação em trabalhos subsequentes nesta área.

A partir de Blundell e Bond (1998), são propostas as seguintes condições de momento adicionais[3]:

$$E\left[\left(y_{i,t-1}-y_{i,t-2}\right)\left(\eta_i+\varepsilon_{i,t}\right)\right]=0 \tag{3.11}$$

e

$$E\left[\left(X_{i,t-1}-X_{i,t-2}\right)\left(\eta_i+\varepsilon_{i,t}\right)\right]=0 \tag{3.12}$$

para $t=4,5,...,T$.

Para que lags das primeiras diferenças sejam instrumentos válidos para as equações em níveis, é necessário que se faça uma última hipótese acerca da estacionaridade das séries, qual seja:

$$E\left(\eta_i \triangle y_{i,2}\right)=0 \quad E\left(\eta_i \triangle X_{i,2}\right)=0 \tag{3.13}$$

Essa hipótese, conforme advertimos anteriormente, requer uma restrição de estacionaridade nas condições iniciais.[4] A hipótese (13) será satisfeita se as médias das séries forem constantes no tempo para $t=1,2,...,T$, e para cada $i \in \{1,2,...,N\}$, podendo, obviamente, difererir entre eles. Temos, portanto, que se o conjunto de hipóteses formado pelas equações (4) a (6) e (13) implica na validade das condições de momento (11) e (12). Por fim, Blundell e Bond (1998) mostram que a combinação das equações (3) a (6) e (13) implica em um conjunto completo de restrições de momento de segunda-ordem, os quais podem ser implementados como um estimador GMM linear, que ficou conhecido como estimador GMM sistêmico.

A hipótese (13), adicionalmente imposta, pode ser interpretada da seguinte forma: apesar de os níveis das variáveis do lado direito da equação de regressão (3) potencialmente serem correlacionados com o efeito não-observável específico a cada país, suas primeiras diferenças não o são. Isso faz com que os lags dessas primeiras diferenças possam ser adequadamente utilizados como instrumentos das equações em nível, tal como anteriormente vislumbrado em Arellano e Bover (1995). O estimador GMM sistêmico, portanto, apenas adiciona ao conjunto de instrumentos para as equações em primeiras-diferenças (proposto pelo estimador GMM em diferenças e formado pelos lags dos níveis das séries), um grupo adicional de instrumentos para as equações em níveis, que nada mais são do que os lags das primeiras diferenças.

À primeira vista, estas condições adicionais podem erroneamente parecer apenas extensões pouco importantes ao estimador anteriormente proposto. No entanto, simulações de Monte Carlo conduzidas por Blundell e Bond (1995) compararam o desempenho de ambos os estimadores em amostras finitas e mostraram que há melhorias dramáticas de performance quando o parâmentro autorregressivo é moderadamente alto e o número de observações das séries temporais é moderadamente baixo. Em outras palavras, quando as séries são persistentes e a dimensão temporal do painel é pequena relativamente à cross-country, a substituição do estimador GMM em diferenças pelo estimador GMM sistêmico é capaz de reduzir substancialmente o viés em pequenas amostras e aumentar a precisão das estimativas dos parâmetros.

[3] O uso dos lags das primeiras diferenças como instrumentos para equações em níveis já havia sido sugerida por Arellano e Bover (1995)

[4] Uma discussão dessas restrições é realizada em Blundell e Bond (1998) e, de forma detalhada, também no apêndice em Bond et al (2001).

3.3.3 Resultados

A Tabela 5 traz os resultados provenientes da estimação da equação de regressão de crescimento econômico, estimada por GMM Sistêmico.[5] Enquanto a Regressão 1 leva em consideração todas as variáveis de interesse listadas na seção 2, a Regressão 2 considera apenas os regressores estatisticamente significantes ao nível de significância de 5% na Regressão 1, reestimando seus coeficientes, para que possamos realizar de maneira consistente as projeções da próxima seção.

De acordo com os resultados da Regressão 1, note que o coeficiente do "nível inicial do PIB per capita" é negativo e estatisticamente significante. Esse resultado vai de encontro com a correlação positiva reportada pela Tabela 2, e indica que, na verdade, há convergência condicional. O valor do coeficiente estimado implica em uma velocidade de convergência de 6,86% ao ano, o que corresponde a uma meia-vida de aproximadamente 10 anos.[6] Isso implica que, em 10 anos, espera-se que metade da diferença entre o produto de dois países distintos desapareça exclusivamente devido à convergência entre os países da amostra.

No que se refere à reversão cíclica, o coeficiente estimado para o "hiato do produto" inicial contemporâneo também é negativo e significante. Isso equivale a dizer que as taxas de crescimentos das dos países da amostra obedecem um processo de reversão à média. De acordo com este resultado, se uma determinada economia se encontra em recessão (expansão) em um determinado período, espera-se que suas taxas de crescimento sejam maiores (menores) nos períodos consecutivos, de forma a reduzir o gap entre o produto observado e o potencial. Já o "hiato do produto"defasado em um período é positivo e significante. Ou seja, o processo de reversão à média só pode ser identificado no período mais recente da estimação.

Por sua vez, todo os coeficientes das diferentes áreas de política estrutural consideradas na regressão apresentam os sinais esperados. Contudo, apenas os coeficientes das variáveis que representam abertura comercial ("valor de comércio ajustado pela estrutura") e infraestrutura ("linhas telefônicas/1000hab) são estatisticamente significantes a 5% de significância.

A não-significância do coeficiente estimado para a variável de educação pode ser atribuída à dificuldade de se encontrar, ou mesmo construir, uma proxy de fato apropriada para este subgrupo de política, uma vez que as bases de dados contendo índices que buscam captar a capacidade cognitiva dos agentes ainda não apresentam um número suficiente de observações para estudos em painel. Por outro lado, se lançarmos uma interpretação mais cética sobre este resultado, surge a desconfiança de que ele pode, na verdade, corroborar os alertas promovidos por Bills e Klenow (2001) acerca da real importância do impacto da educação sobre o crescimento econômico dos países. Como forma de testar a robustez deste achado, substituímos a variável "anos médios de escolaridade" por "taxas de matrículas no ensino secundário" e estimamos novamente os coeficientes da regressão, não havendo, contudo, qualquer alteração digna de nota.

No que tange às políticas de estabilização, apesar de ambas as variáveis apresentarem os sinais esperados, apenas a variável "inflação", que representa ausência de estabilidade nos preços, é estatísticamente significativa a 10% de significância.

Por fim, o coeficiente estimado para a taxa de crescimento dos termos de troca é positivo e estatisticamente significante. Isso equivale a dizer que choques negativos nos termos de troca tendem a reduzir a taxa de crescimento da economia prejudicada pela alteração das condições externas. No que diz respeito às dummies de tempo, podemos observar incrementos no crescimento econômico em relação ao período benchmark, 1971-1975, exceto Tudo o mais constante, apenas observa-se declínio das taxas de crescimento ocorreu na primeira metade dos anos 2000.

[5] **(*) denota significância ao nível de 5(10) por cento. Números em parênteses são as estatísticas T (consistentes com erros-padrão robustos). As regressões incluem um intercepto e variáveis dummy de tempo.

[6] A velocidade anual de convergência em um modelo de crescimento econômico neoclássico, linearizado em torno do steady state, é dada pela fórmula $V = (-1/T) * ln(1 + T * \alpha)$,em que T denota o comprimento de cada período (no caso estudado, T=5) e alpha é o coeficiente estimado para o nível inicial do PIB per capita. Por sua vez, a meia-vida é dada por $HL = ln(2)/V$

A Tabela 5 também fornece os resultados dos testes para zero autocorrelação nos erros em primeira diferença (Arellano-Bond) e para restrições sobreidentificadas (Hansen). Para esses testes, quando a hipótese nula não pode ser rejeitada, o modelo está corretamente especificado. Conforme se observa, não podemos rejeitar a hipótese nula no teste de autocorrelação de segunda ordem - AR(2), as condições de momento usadas no teste são válidas. Por fim, o resultado Teste Hansen aponta para a não rejeição da hipótese nula, isto é, para a validade das restrições sobreidentificadas.

Quando regredimos a taxa de crescimento econômico apenas sobre as variáveis estatisticamente significantes ao nível de 5% na especificação da Regressão 1, obtemos os resultados descritos pela Regressão 2. Note que os sinais dos coeficientes continuam a ser os esperados e que todos os regressores continuam a ser estatisticamente significantes a 5% de significância. Faremos uso destes coeficientes para realizar as projeções e o exercício contrafactual das próximas seções.

Table 3.5: Resultados da Estimação da Equação de Crescimento

Regressão de Crescimento Econômico
Variável dependente: taxa de crescimento do PIB per capita
Amostra: 83 países, 1966-2010
(non-overlapping 5-year period observations)

Variável Explicativa	**Regressão 1**	**Regressão 2**
PIB per capita inicial (log)	-0.0818105**	-0.0928426**
(Convergência Transicional)	(34.94)	(46.67)
Hiato do produto inicial (log)	-.05523284**	-0.6347467**
(Reversão Cíclica)	(-4.16)	(-4.03)
L.(Hiato do produto inicial (log))	0.6279307**	0.7600149**
(Reversão Cíclica)	(3.65)	(3.74)
Anos médios de escolaridade	0.0612823	
(Educação)	(1.42)	
Crédito doméstico/PIB (log)	0.0082218	
(Desenvolvimento Financeiro)	(0.35)	
Volume de comércio ajustado (log)	0.0746276**	0.1638072**
(Abertura Comercial)	(2.05)	(4.37)
Consumo final do governo/PIB (log)	-0.0476211	
(Fardo Governamental)	(-1.32)	
Linhas telefônicas/1000hab (log)	0.0542418**	0.0935361**
(Infraestrutura)	(2.45)	(7.62)
Inflação (log((1+dp)*100)	-0.0287416*	
(Ausência de Estabilidade de Preços)	(-1.80)	
Desvio-padrão do hiato do produto	-0.0062718	
(Ausência de Estabilidade do Produto)	(-0.01)	
Taxa de Crescimento dos Termos de Troca	0 .0579929**	0.0470803*
(Choques nos Termos de Troca)	(2.83)	(1.64)
Shift 2	0.1766808**	0.1798606**
	(6.01)	(7.38)
Shift 3	0.1263835**	0.1161916**
	(4.44)	(4.81)
Shift 4	0.0439319	0.062331**
	(1.59)	(3.04)
Shift 5	0.0601659**	0.0934474**
	(2.64)	(5.32)
Shift 6	0.0164778	
	(0.97)	
Shift 7	dropped	
Shift 8	-0.0135882	-0.0207772**
	(-1,30)	(-2.06)
Shift 9	0.0018236	
	(0.11)	
cons	0.7028516**	0.4495207**
	(2.89)	(3.53)
Instrumentos	74 (t-4)	68 (t-1),(t-2)
Testes de Autocorrelação (p-values)		
Segunda Ordem - AR(2)	(0.066)	(0.516)
Testes de Restrições Sobreidentificadas		
Hansen	(0.129)	(0.320)

3.4 Projeções

No capítulo anterior, estimamos os coeficientes de cada uma das variáveis que foram consideradas determinantes do crescimento econômico na regressão proposta. A partir dessas estimativas, é possível verificar a contribuição de cada um dos grupos de determinantes para a variação esperada do crescimento econômico em cada país e, ainda, comparar estas mudanças, projetadas pelo modelo, com os valores "verdadeiros", ou seja, aqueles obtidos a partir dos dados das séries de tempo. Ao procedermos desta forma, estaremos, portanto, avaliando o desempenho do modelo proposto em explicar o crescimento econômico destes países.

As projeções que faremos nas seções a seguir partem da equação de regressão de crescimento econômico, apresentada na seção 3.2:

$$y_{i,t} - y_{i,t-1} = \rho y_{i,t-1} + \beta' X_{i,t} + \mu_t + \eta_i + \varepsilon_{i,t} \tag{3.14}$$

para $i = 1, ..., N$ e $t = 2, ..., T$.

A mudança no taxa de crescimento econômico de um país, avaliada entre dois períodos (subsequentes ou não) de cinco anos, é obtida ao tomarmos a s-ésima diferença da equação (14):

$$\begin{gathered}(y_{i,t} - y_{i,t-1}) - (y_{i,t-s} - y_{i,t-s-1}) = \\ = \rho\left(y_{i,t-1} - y_{i,t-s-1}\right) + \beta'\left(X_{i,t} - X_{i,t-s}\right) + \left(\mu_t - \mu_{t-s}\right) + \left(\eta_i - \eta_i\right) + \left(\varepsilon_{i,t} - \varepsilon_{i,t-s}\right)\end{gathered} \tag{3.15}$$

para $i = 1, ..., N$, $t = 2, ..., T$, $s = 1, ..., T-1, s < t$.

Note que para calcularmos a variação entre taxas de crescimento econômico obtidas para dois períodos distintos, não se faz necessário estimar o componente não observável (η_i).

A variação esperada (ou projetada pelo modelo) é, dessa forma, obtida a partir da equação (16), na qual constam os coeficientes estimados para cada variável explicativa da regressão de crescimento:

$$E\left[(y_{i,t} - y_{i,t-1}) - (y_{i,t-s} - y_{i,t-s-1})\right] = \hat{\rho}\left(y_{i,t-1} - y_{i,t-s-1}\right) + \hat{\beta}'\left(X_{i,t} - X_{i,t-s}\right) + \left(\hat{\mu}_t - \hat{\mu}_{t-s}\right) \tag{3.16}$$

para $i = 1, ..., N$, $t = 3, ..., T$, $s = 1, ..., T-1, s < t$.

Para a avaliação de variações entre dois períodos subsequentes de cinco anos, as equações (15) e (16) podem ser reescritas como:

$$\begin{gathered}(y_{i,t} - y_{i,t-1}) - (y_{i,t-1} - y_{i,t-2}) = \\ = \rho\left(y_{i,t-1} - y_{i,t-2}\right) + \beta'\left(X_{i,t} - X_{i,t-1}\right) + \left(\mu_t - \mu_{t-1}\right) + \left(\eta_i - \eta_i\right) + \left(\varepsilon_{i,t} - \varepsilon_{i,t-1}\right)\end{gathered} \tag{3.17}$$

e

$$E\left[(y_{i,t} - y_{i,t-1}) - (y_{i,t-1} - y_{i,t-2})\right] = \hat{\rho}\left(y_{i,t-1} - y_{i,t-2}\right) + \hat{\beta}'\left(X_{i,t} - X_{i,t-1}\right) + \left(\hat{\mu}_t - \hat{\mu}_{t-1}\right) \tag{3.18}$$

para $i = 1, ..., N$, $t = 3, ..., T$.

A equação (18), portanto, nos fornece a variação esperada (ou projetada) na taxa de crescimento de um país entre dois períodos de cinco anos subsequentes. Além disso, a partir dela podemos verificar também quais variáveis contribuíram de forma mais substancial para o crescimento econômico de cada país.

3.4.1 Comparação entre Décadas

Em um primeiro momento, nos dedicaremos em obter e analisar as variações das taxas de crescimento econômico entre duas décadas subsequentes. Como as observações da amostra são formadas por médias de cinco anos, e os coeficientes foram estimados a partir delas, partiremos da equação (15) para encontrarmos variações entre décadas subsequentes que sejam consistentes com essas observações.
Fazendo $s = 2$ na equação (15) obteremos:

$$(y_{i,t} - y_{i,t-1}) - (y_{i,t-2} - y_{i,t-3}) =$$

$$= \rho\,(y_{i,t-1} - y_{i,t-3}) + \beta'\,(X_{i,t} - X_{i,t-2}) + \left(\mu_t - \mu_{t-2}\right) + (\eta_i - \eta_i) + (\varepsilon_{i,t} - \varepsilon_{i,t-2}) \tag{3.19}$$

Rearranjando o lado esquerdo da equação (19), obteremos:

$$(y_{i,t} - y_{i,t-2}) - (y_{i,t-1} - y_{i,t-3}) =$$

$$= \rho\,(y_{i,t-1} - y_{i,t-3}) + \beta'\,(X_{i,t} - X_{i,t-2}) + \left(\mu_t - \mu_{t-2}\right) + (\eta_i - \eta_i) + (\varepsilon_{i,t} - \varepsilon_{i,t-2}) \tag{3.20}$$

De maneira análoga à equação (19), podemos escrever:

$$(y_{i,t-1} - y_{i,t-2}) - (y_{i,t-3} - y_{i,t-4}) =$$

$$= \rho\,(y_{i,t-2} - y_{i,t-4}) + \beta'\,(X_{i,t-1} - X_{i,t-3}) + \left(\mu_{t-1} - \mu_{t-3}\right) + (\eta_i - \eta_i) + (\varepsilon_{i,t-1} - \varepsilon_{i,t-3}) \tag{3.21}$$

Rearranjando (21):

$$(y_{i,t-1} - y_{i,t-3}) =$$

$$= (y_{i,t-2} - y_{i,t-4}) + \rho\,(y_{i,t-2} - y_{i,t-4}) + \beta'\,(X_{i,t-1} - X_{i,t-3}) + \left(\mu_{t-1} - \mu_{t-3}\right) + (\eta_i - \eta_i) + (\varepsilon_{i,t-1} - \varepsilon_{i,t-3}) \tag{3.22}$$

Substituindo (22) em (20), temos:

$$(y_{i,t} - y_{i,t-2}) - (y_{i,t-2} - y_{i,t-4}) - \rho\,(y_{i,t-2} - y_{i,t-4}) - \beta'\,(X_{i,t-1} - X_{i,t-3}) -$$
$$- \left(\mu_{t-1} - \mu_{t-3}\right) - (\eta_i - \eta_i) - (\varepsilon_{i,t-1} - \varepsilon_{i,t-3}) =$$

$$= \rho\,(y_{i,t-1} - y_{i,t-3}) + \beta'\,(X_{i,t} - X_{i,t-2}) + \left(\mu_t - \mu_{t-2}\right) + (\eta_i - \eta_i) + (\varepsilon_{i,t} - \varepsilon_{i,t-2}) \tag{3.23}$$

$$(y_{i,t} - y_{i,t-2}) - (y_{i,t-2} - y_{i,t-4}) =$$
$$= \rho\left[(y_{i,t-1} + y_{i,t-2}) - (y_{i,t-3} + y_{i,t-4})\right] + \beta'\left[(X_{i,t} + X_{i,t-1}) - (X_{i,t-2} + X_{i,t-3})\right] +$$

$$+ \left[\left(\mu_t + \mu_{t-1}\right) - \left(\mu_{t-2} + \mu_{t-3}\right)\right] + \left[(\varepsilon_{i,t} - \varepsilon_{i,t-1}) - (\varepsilon_{i,t-2} - \varepsilon_{i,t-3})\right] \tag{3.24}$$

Por fim, aplicando o operador esperança:

$$E\left[(y_{i,t} - y_{i,t-2}) - (y_{i,t-2} - y_{i,t-4})\right] =$$
$$= \hat{\rho}\left[(y_{i,t-1} + y_{i,t-2}) - (y_{i,t-3} + y_{i,t-4})\right] + \hat{\beta}'\left[(X_{i,t} + X_{i,t-1}) - (X_{i,t-2} + X_{i,t-3})\right] +$$

$$+ \left[\left(\hat{\mu}_t + \hat{\mu}_{t-1}\right) - \left(\hat{\mu}_{t-2} + \hat{\mu}_{t-3}\right)\right] \tag{3.25}$$

A equação (25), portanto, nos informa a variação esperada na taxa de crescimento econômico entre duas décadas consecutivas, bem como o peso de cada variável para este resultado.

A Tabela 6 a seguir apresenta comparações entre as décadas 2000 e 1990. Isto é, ela traz, para os 18 países da amostra que pertencem à região da LAC, a variação observada na taxa de crescimento econômico no período considerado, a mudança esperada (projetada pelo modelo) desta taxa, e a contribuição de cada um dos grupos de determinantes do crescimento para esta mudança projetada.

Além disso, ela informa, para todos os países, qual percentual da variação da taxa de crescimento é explicado pelo modelo (mudança projetada/mudança observada.

Observe que o modelo consegue projetar variações na taxa de crescimento próximas das observadas para a Bolívia, Chile e Honduras. Em comparação com a década de 1990, políticas estruturais foram as principais responsáveis por variações positivas no crescimento econômico de Honduras e condições externas para Bolívia e Chile na década de 2000. Nesses dois países, contudo, o efeito negativo das políticas estruturais mais do que compensou os efeitos positivos dos outros grupos de variáveis, sendo, portanto, o único responsável pela deterioração das taxas

de crescimento econômico, durante a década considerada.

Por sua vez, tanto convergência transicional quanto reversão cíclica contribuíram negativamente para o crescimento de Honduras, enquanto que para Bolívia e Chile ambos os efeitos foram positivos.Por fim, as condições externas

promoveram alterações positivas de grande magnitude relativa nas taxas de crescimento de Bolívia e Chile, refletindo uma melhora do ambiente internacional e dos termos de troca.

O resultado da década parece, portanto, ter sido positivo para Honduras e negativo para Bolívia e Chile. No mais, as variações observadas foram superiores às projetado pelo modelo, isto é, de magnitude superior a que as variáveis políticas e econômicas do modelo foram capazes de captar.

Table 3.6: Comparação entre décadas - 2000 vs. 1990

COMPARANDO DÉCADAS 2000 vs. 1990 País	Mudança Observada	Mudança Projetada	Projetada/ Observada (%)	Determinantes da Taxa de Crescimento Econômico Convergência Transicional (% projetada)	Reversão Cíclica (% projetada)	Políticas Estruturais (% projetada)	Políticas de Estabilização (% projetada)	Condições Externas (% projetada)
Argentina	-0,0077	0,0704	-919,3576	-34,7747	-16,1431	446,7234	0,0000	-295,8056
Bolivia	-0,0096	-0,0088	91,6747	126,9000	219,5877	-2309,8605	0,0000	2063,3728
Brasil	0,1470	0,0549	37,3257	-15,7805	17,8901	508,5190	0,0000	-410,6286
Chile	-0,2395	-0,1214	50,6816	72,1135	10,3280	-120,6575	0,0000	138,2160
Colômbia	0,0311	-0,2095	-673,7655	14,9912	21,0680	-26,3736	0,0000	90,3145
Costa Rica	0,0443	-0,1025	-231,6483	37,2155	13,0586	-169,3895	0,0000	219,1153
República Dominicana	0,0882	-0,1531	-173,6583	23,2290	-46,8918	-3,6006	0,0000	127,2634
Equador	0,1416	-0,0662	-46,7581	10,5552	65,7188	-255,6044	0,0000	279,3304
El Salvador	-0,1121	0,0278	-24,8055	-152,9782	69,9114	981,8176	0,0000	-798,7508
Guatemala	-0,0494	0,1093	-221,5265	-14,8575	7,9111	300,1111	0,0000	-193,1647
Honduras	0,1429	0,0714	49,9480	-13,3718	-39,8660	466,6574	0,0000	-313,4196
México	0,0221	0,0086	38,8823	-111,4112	14,1934	2556,4635	0,0000	-2359,2457
Panamá	0,1297	-0,3122	-240,6154	9,9409	6,6693	11,1985	0,0000	72,1912
Paraguai	0,0100	-0,1270	-1264,8528	5,4864	32,9113	-111,3083	0,0000	172,9106
Peru	0,3043	0,0811	26,6406	19,5375	19,4345	295,2012	0,0000	-234,1733
Trinidad Tobago	0,4377	.	.	.	.	.	.	.
Uruguai	-0,1195	-1,2880	1078,2329	3,5196	93,7277	-13,6022	0,0000	16,3549
Venezuela	0,1246	-0,0628	-50,3826	-1,6129	-8,7331	-132,4150	0,0000	242,7611

3.4.2 Comparação entre Períodos de 5 Anos

Fazendo uso da equação (18), calculamos a variação esperada (ou projetada) na taxa de crescimento de um país entre dois períodos de cinco anos subsequentes. Analogamente à Tabela 6, a Tabela 7 traz as comparações entre dois períodos de 5 anos subsequentes, quais sejam, 2006-2010 vs 2001-2005. Conforme podemos observar, as previsões se tornam melhores quando comparamos intervalos de 5 anos, relativamente à comparação entre décadas. Neste exercício, o modelo explica pelo menos 60% da variação observada entre as taxas de crescimento nos dois períodos para seis países. São eles: Argentina, Colômbia, República Dominicana, Panamá, Peru e Venezuela.

Note ainda que todos estes países cresceram mais na segunda metade da década de 2000 do que na primeira, e que essa variação positiva foi corretamente captada pelo modelo em todos estes países. No mais, apenas para a Argentina verificamos taxas de crescimento projetadas inferiores às observadas nos dados.

As condições externas foram as principais responsáveis por variações positivas no crescimento econômico de todos esses países: Argentina (79,19% da mudança projetada), Colômbia (87,94%), República Dominicana (141,94%), Panamá, 94,66% da mudança projetada), Peru (73,23%) e Venezuela (67,90%).

Em seu turno, políticas estruturais foram responsáveis por cerca de 27,43% do aumento do crescimento no Peru, sendo acompanhado por Panamá (17,40%), Venezuela (15,28%) e Argentina (10.82%). Apenas na Colômbia e na República Dominicana as políticas estruturais impactaram negativamente sobre o crescimento, alcançando o patamar 25 p.p. negativos neste último país. No mais, na República Dominicana, ao resultado negativo das políticas estruturais, combinou-se o da reversão cíclica (-2,73%) e da convergência transicional (-14,25%).

A convergência transicional foi uma força de longo prazo contrária ao crescimento dos países destacados, à exceção da Venezuela, no qual todas as variáveis contribuíram positivamente para o crescimento projetado. Uma vez que a reversão cíclica apenas prejudicou o crescimento da República Dominicana e do Panamá no período considerado, a convergência transicional foi o único responsável por reduzir a variação positiva nas taxas de crescimento de metade destes países

Cabe ressaltar que o modelo conseguiu projetar quase que a totalidade da variação da taxa de crescimento do Panamá no período, refletindo um erro de previsão de apenas 2 pontos percentuais. Conforme destacamos, quase a totalidade da variação do crescimento econômico deste país deveu-se a alterações nas condições externas durante o intervalo analisado.

Table 3.7: Comparação entre intervalos de cinco anos - 2006-2010 vs. 2001-2005

COMPARANDO INTERVALOS DE 5 ANOS								
2006-2010 vs. 2001-2005				Determinantes da Taxa de Crescimento Econômico				
País	Mudança Observada	Mudança Projetada	Projetada/ Observada (%)	Convergência Transicional (% projetada)	Reversão Cíclica (% projetada)	Políticas Estruturais (% projetada)	Políticas de Estabilização (% projetada)	Condições Externas (% projetada)
Argentina	0,38	0,27	71,00	-4,06	14,05	10,82	0,00	79,19
Bolivia	0,10	0,28	284,98	-2,98	-1,74	25,19	0,00	79,52
Brasil	0,10	0,19	186,62	-3,25	-3,18	-8,20	0,00	114,63
Chile	0,07	0,26	367,36	-8,36	14,25	6,51	0,00	87,60
Colômbia	0,15	0,24	159,73	-1,92	16,72	-2,74	0,00	87,94
Costa Rica	0,09	0,24	281,81	-4,45	17,23	2,66	0,00	84,56
República Dominicana	0,11	0,15	132,30	-14,25	-2,73	-24,95	0,00	141,94
Equador	0,08	0,32	379,68	-0,13	17,78	14,10	0,00	68,25
El Salvador	0,00	0,25	-12030,26	-6,24	9,07	12,36	0,00	84,81
Guatemala	0,02	0,22	1072,59	-3,68	-1,88	8,18	0,00	97,37
Honduras	0,07	0,26	366,03	-1,29	21,24	0,20	0,00	79,86
México	-0,01	0,25	-3212,71	-2,10	12,46	6,21	0,00	83,42
Panamá	0,21	0,22	102,38	-4,53	-7,53	17,40	0,00	94,66
Paraguai	0,18	0,32	181,75	0,42	1,09	31,62	0,00	66,87
Peru	0,20	0,31	151,22	-4,57	3,91	27,43	0,00	73,23
Trinidad Tobago	-0,05	0,39	-786,64	-5,82	34,18	15,94	0,00	55,70
Uruguai	0,30	-0,95	-313,14	1,29	124,09	-3,26	0,00	-22,13
Venezuela	0,31	0,32	105,02	1,23	15,59	15,28	0,00	67,90

3.4.3 Comparação entre Termos de Troca Fixos e Variáveis

Em que medida os termos de troca favoráveis foram responsáveis pela elevação das taxas de crescimento entre a primeira e a segunda metades da década de 2000 na região da LAC? Em quanto o resultado seria impactado caso os termos de troca (TOT) não houvessem sofrido alterações ao longo da década em questão? Nesta seção, conduziremos um pequeno exercício contrafactual, buscando esclarecer essas questões.

Na segunda e na terceira colunas da Tabela 8 trazemos, como de costume, as mudanças observadas nas taxas de crescimento e as projetadas pelo modelo. Na quinta coluna, contudo, apresentamos os valores projetados pelo modelo considerando termos de troca fixos. Isto é, em um modelo no qual os termos de troca não se alteram, o ambiente externo produz efeito uniforme sobre todos os países da amostra (captado pelas dummies de tempo). Ademais, as quarta e sexta colunas nos informam o quão bem o modelo consegue fazer o fit dos dados da amostra, enquanto a última coluna nos mostra quão maior é a projeção do variação do crescimento quando deixamos os termos de troca variarem, relativamente à projeção em que eles são mantidos fixos.

Observando os resultados para os 6 países destacados na seção anterior, note que apenas para a República Dominicana e o Panamá o crescimento projetado considerando termos de troca fixos é - ainda que de forma bastante sutil - superior ao que havia sido computado anteriormente.

Dessa forma, à exceção desses dois países, manter os termos de trocas fixos equivale a reduzir consideravelmente as projeções das variações positivas de crescimento.[7] Por exemplo, termos de troca variando são capazes de alavancar as projeções das variações do crescimento em mais de 6% no Peru e mais de 4% na Venezuela..

Em suma, termos de troca podem ser considerados, de fato, um importante determinate do crescimento econômico para os países latino-americanos ao compararmos a segunda metade da década passada com a primeira metade.

[7] Apesar de haver um certo decréscimo na capacidade de o contrafactual explicar as variações observadas relativamente ao modelo original para Colômbia, Peru e Venezuela.

Table 3.8: Comparação entre termos de troca variáveis vs. fixos - 2006-2010 vs. 2001-2005

TERMOS DE TROCA VARIANDO x FIXOS
2006-2010 vs. 2001-2005

País	Mudança Observada	Mudança Projetada (TOT variando)	Projetada/ Observada % (TOT variando)	Mudança Projetada (TOT fixos)	Projetada/ Observada % (TOT fixos)	Elevação do Crescimento Projetado (TOT variando vs. TOT fixos)
Argentina	0,3778	0,2683	71,0006	0,2636	69,7651	1,7708
Bolivia	0,0988	0,2817	284,9751	0,2655	268,5488	6,1167
Brasil	0,1017	0,1898	186,6178	0,1800	176,9454	5,4663
Chile	0,0710	0,2609	367,3609	0,2401	338,0696	8,6643
Colômbia	0,1529	0,2442	159,7321	0,2372	155,1378	2,9614
Costa Rica	0,0868	0,2447	281,8089	0,2456	282,7947	-0,3486
República Dominicana	0,1106	0,1463	132,3017	0,1464	132,4045	-0,0776
Equador	0,0841	0,3195	379,6763	0,3092	367,4670	3,3226
El Salvador	-0,0021	0,2470	-12030,2589	0,2453	-11945,9267	0,7059
Guatemala	0,0202	0,2171	1072,5868	0,2135	1054,5929	1,7062
Honduras	0,0718	0,2629	366,0342	0,2607	362,9710	0,8439
México	-0,0077	0,2483	-3212,7066	0,2489	-3221,1448	-0,2620
Panamá	0,2121	0,2171	102,3827	0,2194	103,4414	-1,0234
Paraguai	0,1755	0,3190	181,7549	0,3135	178,5918	1,7711
Peru	0,2040	0,3085	151,2152	0,2904	142,3206	6,2497
Trinidad Tobago	-0,0498	0,3918	-786,6364	0,3813	-765,6341	2,7431
Uruguai	0,3021	-0,9460	-313,1410	-0,9476	-313,6611	-0,1658
Venezuela	0,3094	0,3249	105,0238	0,3121	100,8697	4,1184

3.5 Conclusão

Neste trabalho, buscamos investigar os principais determinantes do crescimento econômico da América Latina e Caribe (LAC), levando em conta alterações no ambiente econômico da última década e contrastamos a importância relativa de condições externas favoráveis com a de políticas públicas adequadas, ambas consideradas motores do crescimento econômico da região.

Motivados pelo fato de que apesar de a última década ter sido extremamente promissora para os países da região da LAC, em termos de evolução do crescimento econômico, há uma nítida desaceleração do crescimento já a partir dos últimos anos da década passada.Inicialmente, descrevemos as principais características do crescimento econômico dos países da LAC e da região, de forma agregada.

Uma vez apontadas diversas similaridades e diferenças no crescimento econômico dos membros da LAC, é necessário compreender se elas se deveram a reestruturações internas nas políticas econômicas e sociais destes países ou a condições externas a eles impostas. Com essa questão em mente, avaliamos empiricamente a contribuição individualizada de cinco grupos de variáveis para o crescimento econômico dos países, por meio de um painel dinâmico. São eles: Convergência Transicional, Reversão Cíclica, Políticas Estruturais (subdivididas em Infraestrutura, Educação, Desenvolvimento Financeiro, Abertura Comercial, e Fardo Governamental), Políticas de Estabilização (subdivididas em Ausência de Estabilidade nos Preços e Ausência de Estabilidade no Produto) e Condições Externas (subdividas em Choques nos Termos de Troca e Condições Globais).

A amostra que é nosso objeto de investigação constitui-se por dados de 83 países, dos quais 18 são da América Latina e Caribe. No mais, trabalhamos com médias de cinco anos, como forma de remover componentes meramente cíclicos das séries. Nosso painel abrange o intervalo de quarenta e cinco anos que se estende desde 1966 até 2010, e é composto, portanto, por nove períodos de (médias) de cinco anos (1966-1970, 1971-1975, 1976-1980, 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, 2006-2010). Contudo, devido ao fato de a observação inicial de cada país se destinar apenas à instrumentação, o primeiro período da regressão se refere aos anos 1971-1975.

Para estimar o modelo empírico de crescimento, utilizamos os estimadores de métodos de momentos generalizados propostos por Arellano e Bover (1995) e Blundell e Bond (1997) - conhecidos como estimadores GMM sistêmicos - os quais são capazes de lidar de maneira apropriada com as especificidades da estimação de um modelo de crescimento dinâmico.

A partir dos coeficientes estimados para cada uma das variáveis consideradas determinantes do crescimento econômico na regressão de crescimento, investigamos a contribuição de cada um dos grupos de determinantes para a variação esperada do crescimento econômico em cada país, por meio de projeções para a variação do crescimento econômico utilizando períodos de 10 e de 5 anos.

No que concerne à análise da variação do crescimento econômico entre 1990 e 2000, dentre outros resultados, destacamos que as condições externas promoveram alterações positivas de grande magnitude relativa nas taxas de crescimento de Bolívia e Chile, refletindo uma melhora do ambiente internacional e dos termos de troca. Nesses dois países, contudo, o efeito negativo das políticas estruturais mais do que compensou os efeitos positivos dos outros grupos de variáveis, sendo, portanto, o único responsável pela deterioração das taxas de crescimento econômico, durante a década considerada.

Por sua vez, no que se refere às projeções entre 2001-2005 vs. 2006-2010, as condições externas também produziram efeitos positivos sobre as taxas de crescimento de todos os países analisados. Em ordem de importância, elas alavancaram o crescimento da Argentina (79,19% da mudança projetada), Colômbia (87,94%), República Dominicana (141,94%), Panamá, 94,66% da mudança projetada), Peru (73,23%) e Venezuela (67,90%).

Isto posto, conduzimos um exercício contrafactual, visando a responder à seguinte pergunta: em que medida os termos de troca favoráveis foram responsáveis pela elevação das taxas de

crescimento entre a primeira e a segunda metades da década de 2000 na região da LAC? Em outras, palavras, buscamos quantificar em quanto o resultado das projeções seria impactado caso os termos de troca (TOT) não houvessem sofrido alterações ao longo da década em questão.

Os resultados do contrafactual apontam que os termos de troca foram, de fato, um importante determinate do crescimento econômico para os países latino-americanos ao longo da década passada.

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