PRODUCTIVITY IN THE BRAZILIAN INFORMATICS INDUSTRY AND PUBLIC SUBSIDIES: A QUANTITATIVE ASSESSMENT♦

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Resumo

O setor de informática (CNAE 30 – máquinas para escritório e equipamentos de informática) é um dos setores que mais crescem no Brasil e no Mundo. É também um dos setores com maior crescimento da produtividade total dos fatores (TFP) e recebe continuado e forte apoio público na forma da Lei de Informática. Apresentamos estimativas inéditas desta produtividade total no setor, e trazemos uma avaliação quantitativa da Lei de Informática na produtividade das empresas. Os resultamos mostram que o impressionante crescimento da TFP no setor de informática está associado ao tamanho das empresas e é fomentado pela concorrência, em que novas empresas são mais produtivas do que as que saem do mercado. Embora a opinião de agentes do setor seja favorável à Lei de Informática, os resultados quantitativos mostram que a Lei de Informática não induziu o aumento da produtividade nas empresas que o receberam. Ao que parece, empresas menos produtivas na média tendem a obter os incentivos. Os resultados sugerem a necessidade de uma revisão da lei para torná-la mais efetiva.

Palavras-Chave:Setor de Informática; incentives fiscais, produtividade total dos fatores.

Abstract

The informatics industry (ISIC 30 – office, accounting and computing machinery) is one of the fastest growing sectors in manufacturing in the World and in Brazil. It is also one of the sectors with fastest total factor productivity growth (TFP) and receives special tax breaks under the name of the "Informatics Law". We measure previously unknown TFP estimates for the sector, and product and input market heterogeneity and provide a previously unknown quantitative assessment of the "Informatics Law". TFP growth was impressive in the industry, fostered by competition and market selection and is mostly associated with size. The quantitative assessment of the Informatics Law on productivity growth is not significant. Less productive firms apply and obtain Informatics Law benefits more on average. The results recommend a revised design in fiscal incentives.

Key words: Informatics industry; tax incentives, total factor productivity.

JEL Codes:L63, O30, D24

Área 8 - Economia Industrial e da Teconologia

♦ We thank IBGE for data access, as part of a larger joint project with IPEA on understanding Brazilian firm growth, and CNPq and IADB for partial financial support. The statistics presented here have been cleared by IBGE to ensure confidentiality. We are solely responsible for data manipulation and interpretation. The opinions expressed in this paper do not represent the official view of IPEA, IBGE, IADB or UFRJ. We thank comments from Carmen Pagés, James Tybout and seminar participants at UFRJ and USP/RP, as well as research assistance from Leonardo Rocha and Bruno Ottoni (UFRJ) and Eric Jardim and Nayara Lopes (IPEA).

1. INTRODUCTION

The informatics industry is one of the fastest growing sectors in the World and very intensive in technology. Average firm expenses in R&D and average skilled labor employment share are higher than the industrial average in Brazil (IBGE/PINTEC) as well as in other countries. The industry is characterized by significant nominal price decreases, stemming from progress in computing power, other technological advances and fierce competition. Using the US Bureau of Labor Statistics CPI index for personal computers and peripheral equipment, prices fell 11% in nominal terms and more than 50% in real terms from 1996 to 2005 (see also Jorgenson, 2001).

This industry has been one of the growth engines of Asia in the recent decades, particularly for Taiwan, Korea and Japan and, more recently, China, according to Rowen et al (2007), *et al.*. Their synthesis of the Asian experience concludes that firms benefited from participating in international production chains, where there was learning and technology transfer from foreign firms, strong government support (financing and tariffs), and research institutes technology transfers.

In Brazil, the informatics industry has also attracted significant interest from researchers and policy makers. It was a highly protected sector in the 1970´s and 1980´s, with close to total bans on imports of computers in the late 1980´s. There were strong efforts to create an autonomous computer industry in all segments (Evans and Tigre, 1996, Schmitz and Cassiolato, 1992). Radical change came in the 1990´s in the wake of trade liberalization, leading to a homogeneous tariff under Mercosul at 16% and no import licences. While in the early period of liberalization in 1991-1992 it was believed that the industry would disappear, domestic production of computers and peripherals now account for more than 1% of GDP. Employment levels in computer and peripheral manufacturing rose from about 5,000 in 1990 to more than 25,000 in 2005.[1] From 1996 to 2005, ISIC 30 value added increased five fold and sector total factor productivity more than doubled, according to our estimates, while manufacturing productivity rose about 20% only.

The aim of this paper is to understand the Brazilian informatics industry growth, focusing on the productivity distribution and dynamics. In particular, we estimate the impact of the tax subsidies offered by the so called "Informatics Law". This Law provides extensive tax breaks for computers and peripherals manufacturers with a minimum domestic content and undertake a minimum R&D effort (5% of their revenue). The first measure would provide incentives the adoption of import substitution strategies by the benefitted firms and that the second benefit would counterbalance the potential inefficiencies brought by the first one, resulting in more innovative strategies and more competitive firms.

Contrary to previous studies (Garcia e Rosalindo, 2004), we use a comprehensive data set of the industry, avoinding the pitfalls of small inquiries. In addition, we use a rigorous impact evaluation methodology, going beyond simple average comparisons, such as SEPIN-MCT/CGEE/GEOPI-UNICAMP (2010). We use firm national firm manufacturing surveys (PIA) to measure productivity in the sector, from 1996 to 2005. In addition we match the data with an Informatics Law beneficiary roster to run econometric estimates on productivity levels and growth determinants. On the other hand, we focus on a very important business dimension, namely productivity. Sustained economic growth and competitiveness ultimately depend on the firm capacity to generate more output with the same amount of inputs, increasing its value added. Productivity gains are the ultimate effect of innovation and R&D.

Our econometric analysis of productivity follows Hsieh and Klenow (2008) in calculating a multi-input disembodied technology index from a Cobb-Douglas production function under monopolistic competition in the product market. These simplifying hypothesis allow us to calculate a

[1] Data from *Panorama do setor de informática 1991* and RAIS/MTEC, respectively. In 1990 the informatics industry employed about 100,000 workers according to the same source. Yet at least two thirds were in "data processing", that has been largely automated since the last decade, and another large share was on software development, that is not classified under ISIC 30.

true total factor productivity index (TFP) from revenue data (Takayama, Lu and Tybout, 2009). In addition, we calculate the more common revenue based TFP measure that depends on output and input prices and firm heterogeneity in labor and capital shares. Both these measures provide a better assessment of productivity that value added per worker as the later increases by simple capital accumulation, but with no potential effect on costs or greater value added. Within sector heterogeneity can generate firm productivity differentials and aggregate output losses from misallocation if the differentials are considered not generated by the market. We evaluate whether firm productivity can be explained by observable characteristics, particularly, age and size, labor quality and international trade. These can be used design policy instruments.

An important source of the heterogeneity of the output price and the capital cost across firms is the beneficial treatment from the so called "Informatics Law". We evaluate whether receiving this benefit has positive impacts on productivity. In principle, there shouldn´t be any effect on true productivity, unless firms innovate when implementing the PPB or are self selected from a low TFP pool. On the other hand, we expect a positive effect on revenue TFP as output prices are differentiated for the firms that receive the benefit from the law.

Advancing our quantitative results, the significant productivity growth was experienced by most of the firms. Competition was an important productivity gain ledge, as less productive firms exited over time, giving room to younger, more productive firms. Firms that use imported inputs have higher TFP even after controlling for unobserved characteristics, subscribing the idea that links to international productive chains are key in the industry. Yet, there is no significant link between Informatics Law benefits and productivity. The simple mean *negative* TFP difference for firms that receive the Law benefits become insignificant once firm observed and unobserved characteristics are controlled for. This suggests low TFP firms self select for Informatics Law benefits, so to compensate their less competitive position.

The article is divided as follows. The first section presents the industry in Brazil, with basic statistics and main policies to the sector, including a description and discussion of the Informatics Law. The second has the analysis of the productivity in the sector and the impacts of the Informatics Law. Final comments conclude the article.

2. BRAZILIAN ISIC 30 SECTOR: BASIC FACTS AND INDUSTRIAL POLICY.

The Informatics sector is one of the fastest growing sector in the economy since the mid 1990´s expanding at a faster pace than GDP. Its value added increased three fold from 1997 to 2007, while share in GDP increased from 0.9 to 1.2% (Table 1). The number of firms and employees also grew over time, but with a somewhat gentler trend. The number of employees rose 2,5 times from 1996-2005, from approximately 10,000 workers to 26,000 in 2005.

Table 1 – Value Added and GDP Share – ISIC 30 (Informatics) Industry – Brazil, 1996-2006

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
V.A.(R$MM)	7.52	8.79	9.65	10.59	12.81	14.73	13.39	16.70	20.62	24.43	29.42
GDP Share	0.89	0.94	0.99	0.99	1.09	1.13	0.91	0.98	1.06	1.14	1.26

Source: IBGE – National Accounts.

Sector sales growth has been followed by international trade growth in final goods (Table 2) and components and parts (Table 3).[2] Over the 1996-2005 period, its revenues grew approximately 30% a.a. in real terms, while revenue growth in the manufacturing sector was only 2% a.a.. The correlation between revenues and parts imports suggests that the sector relies heavily on imported

[2] The components and parts sector also supplies the industrial automation, telecommunications and the consumer electronic sectors. While not included in ISIC 30, we include the data for comparison purposes.

inputs. The growth in exports has been steady over the period, indicating some degree of competitiveness for domestic producers. The negative growth in 2002 was due to the economic crisis for the period and the valuation of the exchange rate seems to be explaining the negative growth of exports in 2007.

Table 2 – Revenue and international trade in the informatics sector- Brazil (US $ million)

Year	1997	1998	1999	2000	2001	2002
Revenues	8,148	8,311	5,856	7,047	6,263	4,576
Annual growth rate		2.0	-29.5	20.3	-11.1	-26.9
% exports/ revenues	3.1	2.8	5.5	4.9	4.1	2.6
% imports/ revenues	15.1	13.1	14.6	15.3	16.6	16.1
Year	2003	2004	2005	2006	2007	2008
Revenues	5,438	7,049	10,039	13,512	16,138	19,199
Annual growth rate	18.8	29.6	42.4	34.6	19.4	19.0
% exports/ revenues	3.6	3.7	3.9	3.0	2.1	1.6
% imports/ revenues	12.1	11.0	10.1	10.4	11.7	11.7

Sources: MDIC e ABINEE

Table 3 - Revenue and international trade growth in the components sector in Brazil (US $ million)

Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Revenues	2,573	2,456	2,204	2,587	2,237	2,022
Annual growth rate		-4.5	-10.3	17.4	-13.5	-9.6
% exports/ revenues	41.8	49.8	57.4	58.7	73.2	84.9
% imports/ revenues	201.1	193.4	219.6	255.5	278.5	257.8
Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Revenues	2,239	2,973	3,555	4,322	5,209	5,170
Annual growth rate	10.7	32.8	19.6	21.6	20.5	-0.7
% exports/ revenues	78.6	67	64.3	62.7	60.5	63.9
% imports/ revenues	256.1	263.2	270.5	275.6	262	344.8

Sources: MDIC e ABINEE

Despite the incentive for innovation, the percentage of innovative firms in the informatics industry slightly declined from 71% in 2001/2003 to 69% in 2003/2005. The average expenditure in innovation in the innovative firms also slightly decreased (PINTEC/IBGE). These numbers are already very high in comparison to the Brazilian average. In fact, in 2003/2005 only 34.4% of the Brazilian industrial firms innovated and their average expenditure in innovation in 2005 was 80% lower than the average expenditure of the firms from the informatics industry.

The productive structure of the ISIC 30 sector is surprisingly similar to the US, as seen in Table 4 below, where cost shares are presented. We see that the sector spends very little on energy, and about 50% of its costs are on materials. This is quite similar between the US and Brazil. On the other hand, Brazilian firms are more capital intensive and less labor intensive than US firms.[3]

[3] There is a noticeable decrease in capital service expenditures over time and an increase in Materials use. This may be due to the different deflators used. While the Capital and Labor deflators are the aggregate investment and consumer price indices, respectively, materials (and revenue) is deflated according to the informatics sector price deflator, that experienced a 50% *decrease* over the period (see appendix for details). When considering only capital and labor expenditures, the shares are more stable over time.

Table 4 –Expenditure Shares Evolution for ISIC 30, selected years, Brazil.

Year	Capital	Labor	Energy	Materials	Capital(VA)	Labor(VA)
1996	0.607	0.128	0.001	0.263	0.830	0.170
2000	0.440	0.089	0.001	0.470	0.835	0.165
2005	0.206	0.060	0.004	0.730	0.778	0.222
Average	0.42	0.09	0.01	0.49	0.823	0.177
SIC 357	0.33	0.17		0.50	0.707	0.293

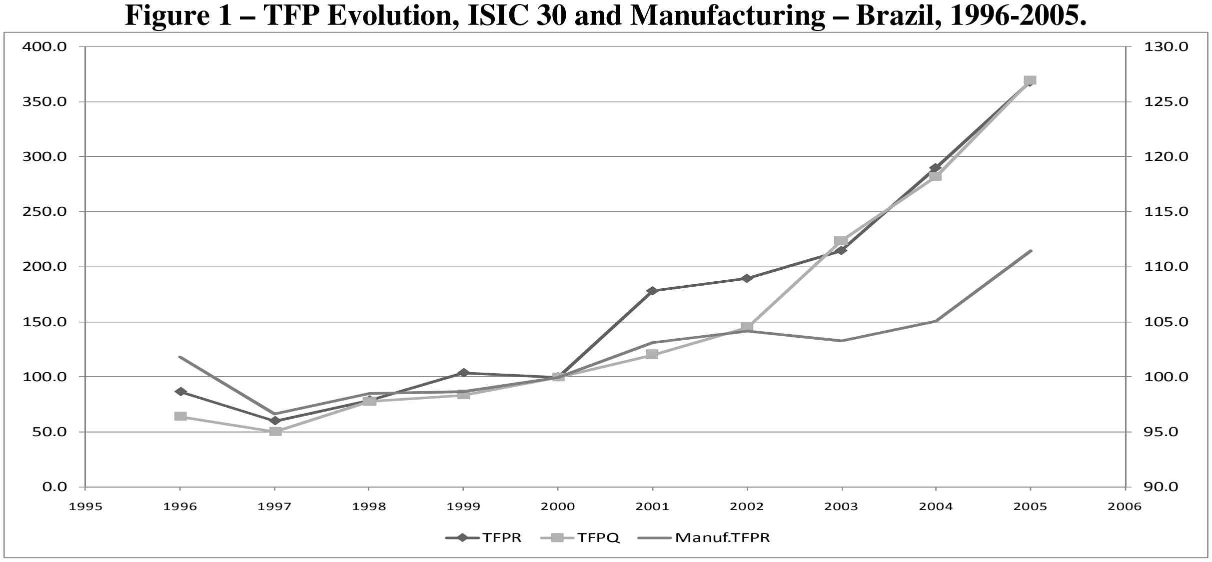
SIC 357 – US average shares for the 1990-1995 period, based on the NBER Productivity Database.
Note: Details on variable definitions, please see Appendix. Authors calculations based on PIA data.

The differing trends for output and input prices amplify the productivity growth over the period. The informatics industry experienced significant growth in total factor productivity measured from sector deflated firm revenue (TFPR) over 1996-2005, as seen in Figure 1, well above the total manufacturing average. It was stagnant up to 2000, following somewhat the aggregate trend, but increasing sharply after 2000. This coincides with a fall in product prices, as seen above. Nevertheless the output price index does not seem to be driven by the exchange rate, as the latter appreciated remarkably only after 2005.

We recognize that the TFP measure based on revenue (or value added) does not truly measure multifactor productivity. An appropriate productivity measure should use output, instead, as Foster, Haltiwanger and Syverson (2008) and Katayama, Lu and Tybout (2009) point out. The revenue TFP actually reflects changes in input and output firm specific and aggregate relative prices and is not related to any true multifactor productivity index.

Under a monopolistic competition model with isoelastic output demand, one can recover output from revenue as in Hsieh and Klenow (2008). With this output measure, we calculate a quantity (value added) based TFP (TFPQ), a true multifactor productivity measure, as described in the Appendix. From Figure 4, it is interesting to note that our TFPQ measure follows the TFPR trend.

Figure 1 – TFP Evolution, ISIC 30 and Manufacturing – Brazil, 1996-2005.



Source: authors´ estimates using raw data from PIA.
Note: All indices normalized to 2000=100. Left axis: ISIC 30 TFPR, TFPQ; Right axis: Manufacturing TFPR.

As an important exploratory device to understand the impressive productivity evolution over time, we use a decomposition of TFP growth, based on Foster, Haltiwanger, and Krizan (2001):

$$\Delta TFP_t=\Sigma_{i\in C}\ \theta_{it-1}\ \Delta tfp_{it} + \Sigma_{i\in C}\ (tfp_{it-1} - TFP_{t-1})\Delta\theta_{it} + \Sigma_{i\in C}\ \Delta\theta_{it}\ \Delta w_{it} + \Sigma_{i\in N}\ \theta_{it-1}\ (tfp_{it} - TFP_{t-1}) + \Sigma_{i\in X}\ \theta_{it-1}\ (tfp_{it-1} - TFP_{t-1}),$$

where TFP_t is the revenue wheighted average (aggregate) productivity for period t,(i.e., $TFP_t=\Sigma_i\ \theta_{it}\ tfp_{it}$) where $\theta_{it}=y_{it}/\Sigma_i\ y_{it}$, i.e., θ_{it} is the share of each firm for total revenue, C indicates continuing firms, N new (entering firms) and X exiting firms. The five terms are interpreted as within(W) and between(B) firm terms, as well as an interaction(I) and net entry (NE) effect.[4] The within effects indicates what share of TFP growth can be attributed to average firm growth, using initial period firm weights, while the between effect summarizes firm reallocation TFP growth.

This decomposition allows us to evaluate whether the TFP growth came from most of the firms, or it was a composition effect with relevante growth of more productive firms. In addition, the decomposition allows us to measure the role of competition, *i.e.* the market selection effect of firm entry and exit.

Overall, the results in Table 5 indicate that a large share of TFP growth came from firm specific growth (W and NE effects), regardless of the TFP measure. The between effect is negative in all periods, for both TFPR and TFPQ, suggesting that more productive firms in the beginning of the period that survived did not experience positive productivity growth. The net entry effect is positive and large for TFPQ, indicating that market selection is contributing to TFP growth.[5] It is troubling to see that initially productive firms actually lost market share and were not capable of sustain competitiveness despite their high productivity. On the other hand, market selection seems to contribute to productivity as the net entry effect is positive (positive NE).

Table 5 – Productivity Growth decomposition – ISIC 30, Brazil

TFPR	W	B	I	NE
1997-2005	0.5056	-0.0996	-0.0803	0.6743
1997-2001	0.3341	-0.1873	0.2300	0.6232
2001-2005	0.7379	-0.1358	0.2118	0.1860

TFPQ	W	B	I	NE
1997-2005	0.4245	-0.1080	-0.0631	0.7467
1997-2001	0.3097	-0.2491	0.2580	0.6814
2001-2005	0.4619	-0.0716	0.1530	0.4567

Note: Authors calculations based on PIA primary data. W- within effect period TFP change share; B – between effect period TFP change share, I – interaction term share, NE – net entry share of TFP change. Entries add up to 1 in each row.

In order to understand the differences between TFPR and TFPQ we calculate Hsieh and Klenow (2008) input and output price within firm differentials, denoted τ_k and τ_y. These differentials, or distortions as in the original paper, are measured as a firm labor input expenditures share differentials with respect to a 4 digit sector average (τ_y), and firm capital and labor shares differentials (τ_k), respectively, under a Cobb-Douglas production function. These differentials may indicate technological differences across firms or true competitive differentials from product

[4] See appendix for calculation details.

[5] Exit effects compares firms that did not survive from the beginning to the last year of period, and Entry rates are based on the productivity evolution of firms that entered after the period first year and survived until the last year of the period. Hence, the firms used in the 2001-2005 comparison are not the same as those used in the 1997-2005 comparison.

differentiation or even tax differentials as the informatics law. The measures are relative, and normalized cross subsectors.

Table 6 – Basic Statistics on output and input differentials – ISIC 30, Brazil

	τ_y			τ_k		
Year	Sd	Q90-Q10	75-Q25	sd	Q90-Q10	75-Q25
1996	1.145	2.812	1.818	0.882	2.069	1.021
2000	1.239	3.062	1.697	0.965	2.246	1.280
2001	1.531	3.928	2.001	1.203	2.917	1.453
2005	1.656	4.013	2.009	1.127	3.130	1.545

Note: Authors calculations based on PIA primary data. See appendix for definitions and data manipulation. The statistics are the standard deviation, 90-10% quantile difference and Interquartile range for firm log(1-τ_y) and log(1-τ_k) standardized by 4 digit means and weighted by value added and the capital stock respectively.

Output price differentials are more disperse than input price differentials across firms. This may be due to the informatics law, that provide sales tax breaks, or plain informality or product differentiation. There is no clear pattern for distortions dispersion over time. The dynamics of τ_y and τ_k are similar, with τ_y exhibiting higher time variance. The distribution may be shown to close to Normal.

In short, TFP growth in the sector has been remarkable. We aim to shed light on the determinants of such productivity growth over time, considering institutions and tax benefits, and other factors. We shall use two alternative methods, namely, interviews with industry leaders and econometric estimates. One particular aspect of the informatics sector is the government support it receives.

2.1 – The 'Informatics Law'

In general, Brazil did not pursue strong industrial policies diring the 1990´s. Recently, two main programs were launched by the Federal Government (*PITCE — Política Industrial e de Comércio Exterior* in 2003 and *PDP – Política de Desenvolvimento Produtivo* in 2008). The informatics sector is one of the few sectors that has always received support. There are substantial differences between the Brazilian environment and incentives to the informatics industry and the economic environment and the incentives given to the same industry by the above mentioned Asian governments. Several of the above mentioned Asian governments closely supervised the integration of their economies in the global economy, including China. One remarkable difference is the weak incentives for ties in international production chains (note that up to 1997, Brazil had a 17% sales tax on exports).

The informatics industry has attracted significant government attention and received benefits not available to other economic sectors, by means of the so-called "Informatics Act".[6] The "Lei de Informática" is actually a series of three laws: Law 8248 (Oct.1991), that came into effect only in 1993; Law 10176 (Jan.2001) and Law 11077 (Dec, 30, 2004). The key benefits of the law are a reduction in the Federal manufacturing goods value added tax (IPI) of up to 95%, for the products certified to follow a PPB (Basic Productive Process), specified by the government, and that invest 5% of its annual revenues on R&D. This last expense also grants to the firm an income tax deduction. Note that the IPI tax rate is usually 15% on ISIC 30 goods.

[6] There is an earlier (pre 1991) set of Informatics Acts, described, e.g., in Evans (1986) and Evans and Tigre (1989) and Fajnzylber (1994). Imports were subject to licenses and production was organized by the Federal Government with strict import controls. This represented a significant effort "to promote indigenous innovation in the computer industry" (Evans and Tigre, 1989). There are also specific policies targeted to software development.

Changes over time of the law were due to either an extension (the 1991 law benefits were to be phased out from 2001) or changes in regional treatments and depreciation treatment of R&D machinery. The PPB is a “minimum set of operations in the plant that characterized the manufacturing – as opposed to assembly – of a specific product” (Law 8.248/1991). The federal government determines the PPB for each new product in the industry. For instance, each of the ink-jet printers producers interested in the tax reduction has to submit to the government its project to follow the ink jet printers guidelines etc. To earn the benefits, each project has to be approved by three distinct Ministries (Science and Technology; Industrial Development and Trade; and the Finance Ministry.

The main purpose of the law was to replace the pre 1991 regulations that actually banned imports. The PPB requirements and tax breaks would provide incentives to firms to internalize as many parts of the manufacturing process as possible. In order to counterbalance the potential inefficiencies brought by this import substitution measure, the law also grants R&D tax incentives. It is argued that higher R&D expenditures should foster product development in the country, lead to knowledge accumulation, higher efficiency and increased competitiveness. [7]

Detailed information on the firms that benefited from the law can be obtained from the website of the “Ministério da Ciência e Tecnologia” of the Brazilian Government. Each product in each plant with approved PPB has its information posted on the Federal Gazette (*Diário Oficial*) and reproduced in the Ministry web site from 2001, where there was a law change. There is no information on previous benefits. Benefits are assigned to a specific product and are valid over the product lifetime, unknown to us.

In 2006 the National Budget Office expected tax breaks from the law to reach US $ 0.8 billion (Exchange rate R$2.00/US$1.00). When merging the data from the MCT with the manufacturing survey (PIA), and restricting the sample to the ISIC 30 firms[8], we estimate that only about 8% of the firms in the industry received the benefit.

Benefit use is quite heterogeneous, increasing with firm size. While the proportion of firms that received the benefit is close to the industry average for firms with less than 99 employees[9], the proportion of large firms (1,000 employees or more) that receive the benefit reach almost 40% (see Table 7). There does not seem to be sharp differences in the proportion of firms that receive the benefit according to firm age.

Table 7 – Proportion of firms that receive tax breaks under Law 10176 and Law11077, according to firm characteristics, ISIC 30, Brazil, 2001-2005.

Age	Share of fims	Size	Share of fims
<=5 yrs	7%	10 – 19	2%
6-10 yrs	4%	20 – 49	9%
11 + yrs	9%	50 – 99	7%
		100 – 249	10%
		250 - 499	19%
		500 - 999	23%
		1000+	38%

Source: authors’ tabulation of raw data from MCT/Brazil and PIA (size) and RAIS (age). Size measured as number of employees.

[7] There are conditionalities on the 5% R&D intensity expenditures. A portion of these expenditures (about 1/3 out of the 5%) must be spent on joint projects with universities or research centers, and 4/9 of those expenditures with centers located in the Northeast and North regions, the poorest regions in the country.

[8] There are a few firms that benefit from the “Lei de Informática” that are actually instruments or mobile phone manufacturers, i.e., outside the ISIC 30 sector. This is allowed under the law.

[9] Curiously, this is the threshold for small firm classification in Brazil.

If we restrict the analysis to firms that innovate or report R&D activities, the PINTEC survey data suggest that at least half the firms in ISIC 30 used such government support. The intensity of use of such benefits is much higher among this subset of firms, as seen in Table 8 below.

Table 8 – Proportion of firms that innovate or report R&D expenditures that receive tax breaks under Law 10176 and Law11077, according to firm characteristics, ISIC 30, Brazil, 2003 and 2005.

Age	Share of fims	Size	Share of fims
<=5 yrs	35%	10 – 19	6%
6-10 yrs	42%	20 – 49	51%
11 + yrs	50%	50 – 99	44%
		100 – 249	78%
		250 - 499	72%
		500 - 999	83%
		1000+	91%

Source: authors' tabulation of raw data from MCT/Brazil and PINTEC (size) and RAIS (age). Size measured as number of employees.

Tabulating on Informatics Law benefits indicates that the number of plants with approved products decreased and then increased over time, somewhat following the business cycle of the informatics industry with a lag of one or two years (Table 9). There is a sharp increase in 2002, reflecting the 2001 posting of the act, a period low in 2004 reflecting the economic downturn from 2002-2003 and a sharp increase in the last years, echoing the sustained economic growth and consumer credit and income boom.

Table 9 – Number of plants receiving tax benefits over time, under Law 10176 and Law11077

Year	Number of plants receiving the Law tax break	Yearly percentage increase	Sector revenue growth
2001	40		-11,1
2002	92	130,0	-26,9
2003	55	-40,2	18,8
2004	17	-69,1	29,6
2005	46	170,6	42,4
2006	53	15,2	34,6
2007	68	28,3	19,4
2008	106	55,9	
TOTAL	477		

Source: authors' tabulation of raw data from MCT/Brazil and PIA/IBGE.

Our data covers the 2000s. During the 90's, the application of the informatics law and its impact has brought strong criticism. According to Garcia and Roselino (2004), in the 1990's most benefits were highly concentrated on few firms. Between 1993 and 2000, 61% of the tax breaks were concentrated on ten firms, and 83% were allocated to 30 firms.

The benefits seem less concentrated after 2001, but certainly not uniform. 18.4% of the tax breaks are now concentrated on ten firms and 34.3% are allocated to 34 firms. Twelve per cent of the firms received 42% of the benefits. One firm alone received up to 41 benefits (a CEM – Contracting Equipment Manufacturing, a component manufacturer). Details available with the authors.

A recurrent critique of the Informatics Law, as means of developing the complete computer industrial productive chain, is that, in practice, the local manufacture of the processor board was all that was required to meet PPB standards. According to Roselino and Garcia (2004) and Gutierrez and Alexandre (2003), firms had little problems to have their projects approved. The former claim that the weak requirements as well as the small scale of the Brazilian market for certain inputs made the Informatics Law unable to actually internalize the manufacturing process. Gutierrez e Alexandre (2003, p. 169), share the same conclusions pointing out that the manufactured goods are designed outside Brazil, and are received as assembly kits. This would shorten the supply chain and hinders any local market for components and parts.

The authors also criticize the 5% minimum R&D level as too high. For example, the world manufacturing firms in the sector (denoted CEMs – Contracting Equipment Manufacturing firms) invest less that 1% on average on R&D in their home countries. The exceedingly high threshold required for the tax benefits, as well as the difficulty to pinpoint R&D expenditures led to great incentives to accounting gerrymandering. They indicate that most expenses were on low value added activities, such as software programming. Another detail of the law is that the 5% R&D expenditures are earmarked on a series of outlets or activities, such as minimum regional expenditures and the requirement of university agreements.

Since 2005 there have been a number of additional benefits to the sector. The most important one was the so called "Lei do Bem" (Goodness Act), Law 11,196 (Nov. 2005) that gave an additional 9.25% tax break on gross revenues (from payroll tax exemption) to all PC´s (desktops or laptops) sold for up to R$2,500 (or approx. US$1,000 at the time of the law). The limit was extended to R$4,000 by 2007.

The joint effect of rising personal income levels, consumer credit supply and government support, led to a sharp increase in informatics goods sales recently. The percentage of poor families with a computer at home is growing. In 2007, 9% (24%) of families who earn between one and two (two and three) minimum wages[10] owned a computer, compared to 3% (6%) in 2005[11]. Similar trends appear for other market segments. For instance, the number of ATMs has increased from 128.724, in 2003, to 166.773, in 2007 (FEBRABAN).

3. PRODUCTIVITY GROWTH IN THE BRAZILIAN ISIC 30 SECTOR – AN EXPLORATORY ANALYSIS

To shed further light on the level, dispersion and growth of our estimated TFP and output and input heterogeneity measures, we ran a number of regressions to identify possible associations of firm observable characteristics and productivity in the Informatics industry in Brazil. These regressions are specified with an eye on the main conclusions from the interviews. The observable characteristics are firm size (measured by log employment), firm age, share of skilled workers (to proxy labor quality), output taxes paid over revenue (i.e., an average revenue tax rate, to proxy beneficial tax treatment), imported input expenditure over value added (to proxy for product quality), trade volume over net revenue (to proxy for participation in international supply chains and unobserved quality) and whether a firm imports and whether it exports. Aggregate trends are controlled for using year dummies. Lagged size and skills are used to minimize endogeneity bias.

[10] A minimum wage is approximately US $ 200.00 using June 2009 exchange rates.
[11] "Survey On The Use Of Information And Communication Technologies In Brazil 2007" - Brazilian Internet Steering Committee.

Export activity and import activity are signals of higher quality (productivity) in the literature. The larger, arguably more productive firms, claimed that there are no skill shortages, while smaller firms appear to have proportionally less skilled workers. Firm size is used to gauge possible scale economics (note that we estimate TFP under a constant returns to scale hypothesis) suggested by interviewees. Trade volume over net revenues reveal if the Asian experience has positively contributed to productivity growth. Taxes paid should not influence TFPQ but are positively correlated with TFPR, as seen in the Appendix, following Hsieh and Klenow (2008).

Few clear patterns show up on Table 10. First, the measurement of TFP does not change the results, even though TFPR and TFPQ measure quite different things, under the monopolistic competition hypothesis. Second, firm size is positively related to productivity, as argued by the interviewees. Third, older firms exhibit smaller productivity, suggesting that there is no learning in this sector. While this may be counterintuitive, note that this result is conditional on size. The learning process seems to be superseded by a vintage effect. Last but not least, except for the use of imported inputs, the other explanatory variables are not significant. It is comforting to see that productivity is not correlated with labor quality, as a correctly measured TFPQ tracks neutral (disembodied) technical progress. Yet, firms that use imported inputs have higher productivity. This may be explained as firms that use imported material or capital either have better quality and command a differential price (in the case of TFPR), or are able to combine better capital and labor to process the better (imported) materials (in the case of TFPQ).

Table 10 – Firm productivity and observable characteristics – ISIC 30 – Brazil 1996-2005.

lnTFPQ

Size	0.6121	***	0.6396	***	0.6619	***	0.6383	***
Age	-0.0788	**	-0.0918	***	-0.0841	**	-0.0722	**
Share skill.	0.1508		0.2099		0.2217		0.0978	
Taxes/Rev			-1.4357		-1.1415		-0.9335	
Imports/VA			-0.0474		-0.0105		-0.026	
Trade Chn.					0.7553		0.8007	
Importer							0.5646	**
Exporter							0.2907	
R^2	0.0959		0.1102		0.1147		0.1336	
F	4.5503		4.2734		4.0679		4.1754	

lnTFPR

Size	0.2925	***	0.3148	***	0.3332	***	0.3202	***
Age	-0.0462	**	-0.053	**	-0.0482	**	-0.0417	*
Share skill.	0.1471		0.1836		0.1908		0.1235	
Taxes/Rev			-0.7795		-0.6077		-0.4968	
Imports/VA			-0.0243		0.0005		-0.008	
Trade Chn.					0.5625		0.5863	
Importer							0.3087	**
Exporter							0.153	
R^2	0.0927		0.1062		0.1138		0.1262	
F	4.385		4.0985		4.0297		3.9098	
Sample	640		624		618		618	

Note: Size: log employment; Share skill.:share of skilled workers; Trade Chn: sum of imports and exports over revenue. *** - signif. at 1% level;** - signif. at 5% level; * - signif. at 10% level. Year dummies included. Fixed Effects estimation.

Table 11 below looks at firm input and output differentials (or distortions). As expected the mean tax-revenue ratio is positively related to the output price distortion.[12] Surprisingly, this type of distortion is unrelated to size, age or other variables. We expected the output differential to be related to size and imports, as larger firms or firms that use imported inputs could use either its market power or product quality to command differentiated prices. It seems that the constant (isoleastic) demand curve is correctly approximating the price differentials across firms.

Table 11 – Firm output and input differentials and observable characteristics – ISIC 30 – Brazil 1996-2005.

	$ln(1-\tau_y)$							
Size	0.1254		0.0979		0.0858		0.0937	
Age	0.0318		0.0400	*	0.0352		0.0312	
Share skill.	0.3623		0.3410		0.3368		0.3797	
Taxes/Rev			1.2089	**	1.0788	*	1.0003	*
Imports/VA			-0.0036		-0.0147		-0.0096	
Trade Chn.					-0.6574		-0.6756	
Importer							-0.1894	
Exporter							-0.1158	
R^2	0.0792		0.089		0.0929		0.0988	
F	3.6881		3.3724		3.2157		2.9669	

	$ln(1+\tau_k)$							
Size	0.5996	***	0.5964	***	0.6016	***	0.5917	***
Age	0.0111		0.0116		0.0128		0.0177	
Share skill.	0.6947	***	0.7269	***	0.7283	***	0.6816	***
Taxes/Rev			0.4202		0.4941		0.5541	
Imports/VA			-0.0106		0.0231		0.0167	
Trade Chn.					-0.1005		-0.0904	
Importer							0.2297	**
Exporter							0.0672	
R^2	0.2476		0.2551		0.2583		0.2711	
F	14.116		11.8156		10.9291		10.0662	
Sample	640		624		618		618	

Note: Size: log employment; Share skill.:share of skilled workers; Trade Chn: sum of imports and exports over revenue. *** - signif. at 1% level;** - signif. at 5% level; * - signif. at 10% level. Year dummies included. Fixed Effects estimation.

On the other hand, the capital-labor relative cost differential (distortion) is positive for larger firms and it increases with the share of skilled workers used by a firm. This suggests that firms with higher employment (our firm size measure) are using too much labor with respect to capital based on a sector average benchmark. On the other hand, the positive association between the share of skilled workers and the relative capital-labor cost could be explained by mismeasurement of the wage rate due to labor input quality. Firms that use more skilled labor seem to pay a wage premium over the industry average relative capital-labor input cost, so that the wage bill is above the industry average, relative to the capital expenditure.

[12] Our taxes over net revenue is measured as (taxes paid)/(gross revenue – taxes paid).

So far our analysis has not focused on the important government support that the industry receives, namely the “Lei de Informática” (Informatics Act) discussed in earlier sections. Information on such benefits can be obtained from 2001 on from the Science and Technology Ministry with individual firm data, as discussed above[13]. We analyze the effects of the in the evolution of productivity in three ways. First, a descriptive model of who receives the benefits. Second, a differences model, with and without controls, to measure the average impact of the law on productivity.

Moving to the first results, it is not easy to typify a firm that receives benefits from the Informatics Act based on observable characteristics. Using the model reported on Table 16, we see that only the information of whether a firm uses imported inputs or exports is relevant for differentiating firm that receive and did not receive the benefit from 2001-2005. The fixed costs of applying do not seem to matter as larger firms are not more likely to receive the benefit than smaller firms.

Table 12 – Logit model for receiving the Informatics Act benefits in a given year on firm observable characteristics, ISIC 30, Brazil, 2001-2005.

Variable	Coeff.	s.e.	t-stat	Variable	Coeff.	s.e.	t-stat
Size	0.102	0.191	0.53				
				5-9 empl.	17.802	1.296	13.74***
				10-19 empl.	16.579	0.978	16.95***
				20-49 empl.	17.636	0.831	21.23***
				50-99 empl.	17.258	0.797	21.64***
				100-249 empl.	17.029	0.714	23.85***
				250-499 empl.	17.655	0.754	23.40***
				500-999 empl.	17.714	0.958	18.50***
6-10 yrs.	-0.602	0.694	-0.87	6-10 yrs.	-0.727	0.669	-1.09
11+ yrs	-0.366	0.699	-0.52	11+ yrs	-0.501	0.621	-0.81
Shr.skilled labor	1.293	1.061	1.22	Shr.skilled labor	1.374	0.949	1.45
Importer	2.567	0.885	2.90***	Importer	2.737	1.031	2.66***
Exporter	0.761	0.435	1.75*	Exporter	0.782	0.483	1.62*

Note: Size: log employment. N=543. *** - signif. at 1% level;** - signif. at 5% level; * - signif. at 10% level. Year and sector dummies included.

Our attempts at evaluating the impact of the Informatics Law on productivity and firm differentials with and without controls appear on Table 13. In general, a firm receives benefits from the informatics law does not influence productivity once observed and unobserved characteristics are controlled for. A simple mean difference (first column) indicates that firms that receive the benefits of the Informatics Act are less productive using either measure of productivity (true productivity TFPQ or revenue productivity TFPR). Once firm characteristics are controlled for, the significance disappears, although unobserved characteristics are more important to distinguish the effect of the informatics law on TFPQ and less so on TFPR (as the significance disappears once observed controls are used in the latter case, before fixed effects are used). The Informatics Law dummy significance changes from pooled estimates to FE suggest that conditionally low productivity firms are the ones that receive Informatics Law benefits. According to the interviews, this can be interpreted as a

[13] There is information on the *Lei de Informática* at PINTEC. This data is not used as there are few firms that can be matched with PIA and the calculated productivity data in the ISIC 30 industry (less than 30 every year of the PINTEC sample, namely 2003 and 2005).

consequence of the productive process conditionalities, precluding the use of more advanced techniques (such as robots). At the same time, these less productive firms have the incentive to seek tax breaks from the Informatics Law to compete.

Table 13, Effect of Informatics Law on productivity, Brazil ISIC 30, 2001-2005.

lnTFPQ

	LS(n.c.)		LS		FE	
Informatics Law	-0.339	*	-0.582	**	-0.143	
Size			0.335	***	0.794	***
Age			0.001		-0.122	***
Share skilled work.			0.269		1.186	*
Importer			-0.210		0.099	
Exporter			-0.036		0.065	
R^2	0.1653		0.3242		0.1461	
F	5.07		7.01		10.89	

lnTFPR

	LS(n.c.)		LS		FE	
Informatics Law	-0.357	**	-0.248		-0.159	
Size			-0.095	*	0.457	***
Age			-0.002		-0.078	***
Share skilled work.			-0.496	*	0.675	
Importer			-0.458	***	-0.046	
Exporter			-0.232	**	0.013	
R^2	0.0703		0.293		0.1061	
F	2.25		17.67		7.56	
Sample	737		645		645	

Note: Size: log employment; Share skill.:share of skilled workers. LS(n.c.):least squares without controls (but for year and sector dummies); LS least squares; FE: fixed effect estimation. *** - signif. at 1% level;** - signif. at 5% level; * - signif. at 10% level. Year dummies included. 4 digit sector dummies included except in Fixed Effects estimation.

Comparing Table 13 with Table 11, we confirm that productivity is positively influenced by size and negatively associated with age, for both TFP measures[14]. Revenue over an input index (TFPR) is better characterized by firm fixed effects than with observable characteristics such as skilled workforce or whether a firm imports or exports. We ran additional regressions using *lagged* benefits of the Informatics Law and the lack of correlation between receiving the tax benefits and productivity conclusion is maintained. Lagged (two year) indicators are used as there may be time needed to reap the benefits of the law in the market or to implement the product line that benefited from the tax break. Results are available upon request.

Finally, Table 14 presents the estimates for the firm specific output price and capital cost differentials. Recall that one of the Informatics Law main benefits is a reduction in the federal value

[14] The result is stronger once we realize that table 18 uses lagged variables and covers the 1996-2005 period and table 21 uses current variables and covers 2001-2005 only.

added tax (IPI) for the goods that have enough domestic content in their manufacturing process (PPB). There are additional benefits regarding depreciation and income (IRPJ) tax treatment of R&D expenses. Interestingly, firms that receive the benefit of the Informatics tax have a higher price than others, on average. An alternative interpretation, as may be seen in the appendix, is that firms that receive Informatics Law benefits spend too much on labor, as a share of value added, on average, than would be expected from a sector benchmark. Yet this differential disappears once unobserved characteristics are controlled for, suggesting that it is not actually the benefit from the Informatics Law that was generating the differential but firm characteristics correlated with price and Informatics Law status.

Table 14, Effect of Informatics Law on firm output and input differentials – ISIC 30 – Brazil 2001-2005.

deviation from sector mean $ln(1-\tau_y)$

	LS(n.c.)		LS		FE	
Informatics Law	0.393	***	0.293	**	0.172	
Size			0.151	***	-0.154	*
Age			-0.007	*	0.019	
Share skilled work.			0.241		0.044	
Importer			-0.524	**	-0.011	
Exporter			-0.005		0.036	
R^2						
F	0.0075		0.1296		0.0177	

deviation from sector mean $ln(1+\tau_k)$

	LS(n.c.)		LS		FE	
Informatics Law	-0.094		0.112		-0.084	
Size			0.059		0.473	***
Age			-0.015	***	-0.016	
Share skilled work.			-0.432		0.777	**
Importer			-1.434	***	-0.033	
Exporter			-0.392	*	0.104	
R^2						
F	0.0106		0.2472		0.1769	
Sample	0.2124		31.27		13.68	

Note: Size: log employment; Share skill.:share of skilled workers. LS(n.c.):least squares without controls (but for year and sector dummies); LS least squares; FE: fixed effect estimation. *** - signif. at 1% level;** - signif. at 5% level; * - signif. at 10% level. Year dummies included. 4 digit sector dummies included except in Fixed Effects estimation.

Regarding the relative capital cost differential *(τ_k)*, there does not seem to be any difference between firms that received and did not receive the benefit, with or without controls. Comparing the rightmost column of the lower half of Table 22 with the rightmost column of the lower half of Table 19, one confirms the results that larger firms and firms that use more skilled workers are the ones with a relative labor expenditure share of input larger than sector average. This difference could be explained by true technology differences (production function coefficients) or misspecification of the wage cost. In the former case, Brazilian technology in the informatics sector seem to be biased towards labor for larger firms. In the latter case, larger firms would face a relatively higher capital costs. This is counterintuitive, particularly in light of BNDES credit, that is subsidized and biased towards large firms, as subscribed by the interviews.

4. CONCLUDING COMMENTS

In this paper we set out to study the informatics industry (ISIC 30) growth and productivity in Brazil. This is a sector that changed radically in the last twenty five years, moving from a virtual ban on imports to an open sector with common Mercosur tariffs. At the same time, there were international changes in manufacturing processes, processing power and applications that reshaped the industry. Computers are now ubiquitous in our lives and their use is intertwined with mobile and digital communication technologies. In Brazil the sector still receives special support from specific legislation giving tax breaks (sales, payroll and corporate taxes) to firms with higher domestic content on their manufacturing process and high R&D expenditures. These benefits are referred to as "Lei de Informática" (*Informatics Act*).

The Brazilian sector experience can be contrasted with the Asian experience, where the informatics, as well as the larger ICT (information and communication technologies) and electronics sectors, are seen as engines of growth. While in the Asian countries the informatics sector has strong international ties, as part of a global productive chain, in Brazil firms usually sell consumer products domestically. They do use international suppliers to tap more advanced technology, but do not participate in global productive chains.

Using manufacturing survey firm level data to study the association between productivity and observed characteristics (and unobserved ones as fixed effects), we provide econometric evidence on the effect of Informatics Law benefits on productivity.

Our productivity analysis followed Hsieh and Klenow (2008), using their analytical framework to estimate revenue productivity and true (output) productivity under monopolistic competition with Cobb-Douglas technology and exploring firm output price and capital relative cost differentials. These differentials also measure firm labor and capital share heterogeneity. The differentials can be interpreted as distortions (non-market generated distortions) under the assumed model or may reflect true within sector technology differentials and or input and output market price differentials.

We estimate significant TFP growth for the sector over time, particularly after 2000. Productivity heterogeneity is increasing also. Decomposing TFP gains from 1996 to2005, we see that most productivity gain was within sector, with a negative contribution of between firm reallocation for continuing firms and a positive market selection (net entry) effect. Regression analysis of TFP on observed and unobserved characteristics indicates that larger firms are more productive and older firms are (conditionally) less productive. When firms use imported inputs their productivity levels are above average.

Informatics Law benefit recipient status does not influence productivity, once firm characteristics, such as size, age and skills are controlled for. The negative effect in simple mean differences and insignificant results from fixed effect estimates suggest that structurally less productive firms are the ones that tend to seek Informatics Law benefits. The law tax breaks seem to lower costs for less productive firms, allowing them to survive, counteracting the pro-productivity market selection effect revealed by the productivity decomposition.

In short, the Informatics industry in Brazil has experienced large and robust productivity growth over the period under study. Domestic firms as well as multinationals seem to be expanding their operations, exploring the low computer use intensity rates in the country. The industry has focused on end-users, with parts and suppliers from abroad, taking a different route than Asian countries. The informatics law seems to be an opportunity foregone, where the emphasis on end products and the internal market (exports are already exempt from the IPI sales tax), as well as the conditionalities on R&D expenditures have limited the effects of the law.

Nevertheless, it must be stressed that we did not propose to evaluate the "*Lei de Informatica*" in its many dimensions, as we focused on productivity. The Informatics Law may have impacts on firm size, value added and innovation that are not accounted for here. These have been considered in SEPIN/CGEE/GEOPI (2010), albeit based on a qualitative analysis. One important issue is whether firms that tap the Informatics Law benefits use less productive technology to begin with, or the domestic content clauses of the Law hinders the use of automated, more productive, technology. This is clearly a topic for future research.

REFERENCES

Castellani, D. And Zanfei, A. Multinational Firms, Innovation and Productivity, Edward Elgar Publishing. Inc. 2006

Ernst, D. and Kim, L. (2002) Global production networks, knowledge diffusion, and local capability formation. *Research Policy* 31(8), 1417-1429

Evans, P. (1986) State, Capital and the Transformation of Dependence: The Brazilian Computer Case. *World Development* 14, 7.

Evans, P. and Tigre, P. (1989) Going Beyond the Clones in Brazil and Korea: A Comparative Analysis of NIC Strategies in the Computer Industry. *World Development* 17, 11

Feenstra, R. (1998). Integration of Trade and Disintegration of Production in the Global Economy, *Journal of Economic Perspectives*, 12(4), p. 31-50.

Foster, L., J. Haltiwanger and C. Syverson (2008). Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitablity? *American Economic Review*

Fajnzylber, P. (1994) A capacitação Tecnológica na Indústria Brasileira de Computadores e Periféricos: do Suporte Governamental à Dinâmica do Mercado). MA Dissertatin, UNICAMP.

Garcia, R. e Roselino, J. E. Uma avaliação da lei de informática e de seus resultados como instrumento indutor de desenvolvimento tecnológico e industrial, GESTÃO & PRODUÇÃO, v.11, n.2, p.177-185, mai.-ago. 2004

Grangnes, G. e Assche, A. V. (2008) China and the future of Asian Eletronics Trade, Scientific Series, CIRANO, Centre Interuniversitaire de recherché en analyse des organizations, Quebec, Canada ISSN 1198-8177

Helpman, E.; Melitz, M. J. And Rubinstein, Y. (2004) Exports versus FDI with heterogeneous firms; American Economic Review 94, pp. 300-316

Hobday, M (2000). East versus Southeast Asian Innovation Systems: Comparing OEM – and TNC – led Growth in Electronics, *in KIM, L. e NELSON, R. Technology, Learning and Innovation: Experiences of* Newly Industrializing Economies, Cambridge University Press,

IBGE (2002) Pesquisa Industrial Inovação Tecnológica 2000 – Análise dos Resultados.

IBGE (2005) Pesquisa Industrial de Inovação Tecnológica – PINTEC 2003. Rio de Janeiro

Igliori, D. C E Diegues Jr., A. C. 2008. Uma Agenda de Competitividade Para a Indústria Paulista de Equipamentos de Informática, Relatório de Pesquisa da FIPE/USP – IPT/SP mimeo, 2008

Jorgenson, D. (2001) Information Technology and the U.S. Economy. *The American Economic Review*, 91: 1-32.

Katayama, H., Lu S. and Tybout. J. (2009). Firm-level Productivity Studies: Illusions and a Solution." *International Journal of Industrial Organization.*

Lall, S. (2000) Technological Change and Industrialization in the Asian Newly Industrializing Economies: Achievements and Challenges. *In Kim, L. and Nelson, R. R. (eds.) Technology,* *Learning and Innovation: the experiences of the newly Industrializing Economies.* Cambridge University Press, 2000

Mathews, J. A. (2006) Dragon Multinationals New Players in 21st Century Globalization, *Asia Pacific Journal of Management* 23: 5–27

OECD (2004) The Economic Impact of ICT Measurement, Evidence and Implications OECD. OECD Publishing, 2004

______ (2008a) *Information Technology Outlook* 2008 – ISBN 978-92-64-05553-7

______ (2008b) *Science, Technology And Industry Outlook* 2008 – ISBN 978-92-64-04991-8

Prochnik, V. And Araújo, R. D., "Analyzing the Low Degree of Innovation in Brazilian Industry by Studying the Least Innovative Firms" (2005). Available at SSRN: http://ssrn.com/abstract=1094305

Prochnik, V., Freitas, F. And Esteves, L. A. (2007) Firm Level Heterogeneity and Internationalisation in Brazilian Industry, Eds: in deNegri and Araújo (op cit).; IPEA, .

Rowen, H., Hancock, M. and Miller, W. (2007) *Making IT*: the rise of Asia in high tech. Stanford University Press.

Saliola, F. and Zanfei, A.(2009) Multinational firms, global value chains and the organization of knowledge transfer *Research Policy*, 38(2), p.369-381

Schmitz, H. e Cassiolato, J. (1992) *Hi-Tech for Industrial Development*, London:Routledge

SEPIN/CGEE/GEOPI (2010) *Resultados Preliminares – relatório projeto de avaliação da lei de informática*. http://www.abinee.org.br/informac/arquivos/ss.pdf

UNCTAD (2007) *Information Economy Report 2007-2008 - Science and technology for development: the new paradigm of ICT*. United Nations Publication: New York and Geneva.

APENDIX A - Variable definitions and estimation details.

We present here the data transformations made to generate the TFP estimates and other variable definitions.

TFP estimates: Total Factor Productivity is calculated using a constant cost share method, using US cost shares, as in Hsieh and Klenow (2008), namely:

$$tfpr_t=\omega_{it}= y_{it} - ((1-\alpha)\, l_{it} + \alpha\, k_{it})$$

where y measures log value added, l is the log labor used (the wage bill) and k the log capital stock; $\alpha = C_K/C$, and C_j represent expenditures on input j $(j=L,K)$ and $C=\sum_j C_j$. This is the measure we denote *revenue* TFP, or TFPR. The capital share is set to the corresponding US level, available at the NBER Produtctivity Data Base, using the 1990-1995 average at the 4 digit level. In detail, we use .2403 for CNAE 3012 (Business machines), .3261 for CNAE 3021 (computers), and .3137 for CNAE 3022 (printers and peripherals).

Following Hsieh and Klenow (2008) an output adjusted TFP measure is dubbed TFPQ and exploits a monopolistic competition model, with demand function $P=Y^{\sigma}$. This implies that output may be recovered from value added using $Y=(PY)^{\sigma/(\sigma-1)}$. The elasticity parameter is set to $\sigma=3$. Thus, log TFPQ is measured as $tfpq_t= (3/2)y_{it} - ((1-\alpha)\, l_{it} + \alpha\, k_{it.})$. Value added ($y$) is measured by the deflated difference between net sales (plus inventory changes) and manufacturing costs (materials and energy costs). The deflator used is an IPA (wholesaleprice index for printers). Results do no change much if computer price indices are used. Labor is measured by the number of permanent workers and labor cost by the total wage bill (including social security payments). The wage bill is deflated using the national inflation index used for minimum wage and retirement earnings adjustments (INPC). The capital stock is calculated from a perpetual inventory model on net investment. Investment is deflated using the price deflator for machinery and equipment (IPA-DI). The estimated capital stock for each year is augmented with rented or leased equipment and buildings values, under a 10% rental rate. The initial capital stock is based on average depreciation expenditures over time, and we use a 5% depreciation rate. Capital expenditures are measured by a 5% cost of capital in addition to rental and leasing expenditures. The rent or leased capital stock adjustments are required so to keep total capital stock from decreasing sharply over time and account for the fact that firms have increasingly used leasing or equipment rent over time.

As in Hsieh and Klenow (2008) we explore within sector firm differences in output prices and relative capital cost. Firm profits are maximized according to $\pi = (1-\tau_{y,it})(PY)_{it} - wL_{it} - (1+\tau_{k,it})rK_{it}$, s.t. $y_{it}=tfpq_{it}+((1-\alpha_s)\, l_{it} + \alpha_s k_{it})$ and $P=Y^{\sigma}$. Note that labor and capital costs (w and r, respectively), as well as technology parameters, are equal to all firms (within a 4 digit sector s). From the profit maximization FOC we can calculate

$$(1-\tau_{y,it}) = \sigma/(\sigma-1)\ (1/(1-\alpha))wL_{it}/(PY)_{it}$$
$$(1+\tau_{k,it}) = (\ \alpha/(1-\alpha))wL_{it}/rK_{it}.$$

It is not hard to see that these factors ($\tau_{y,it}$ and $\tau_{k,it}$) reflect relative differences between the firm capital and labor cost shares and the assumed sector cost shares, where $rK_{it}/(rK_{it}+wL_{it})=\alpha_{it}$, and we use the fact that $(rK_{it}+wL_{it}) = (\sigma-1)/\sigma\,(PY)_{it}$ in our monopolistic competition model with constant returns to scale.

$$(1-\tau_{y,it}) = (1-\alpha_{it})\,/\,(1-\alpha)$$
$$(1+\tau_{k,it}) = [(1-\alpha_{it})\,/\,(1-\alpha)\,]\,/(\ \alpha_{it}\,/\,\alpha\,)$$

Hsieh and Klenow (2008) name $\tau_{k,it}$ $\tau_{y,it}$ as "wedges" or distortions. We use a more general term heterogeneity differences, as some of these distortions may be special treatments some firms receive (as the sales tax benefit of the informatics law) or tax evasion, or may be true factor price or technology differences. Of course each reader prior about factor market prices competitiveness (or absence of adjustment costs and even measurement error) influence the interpretation of the factors $\tau_{k,it}$ and $\tau_{y,it}$.

The estimated output TFPQ measure may be dependent on our monopolistic competition hypothesis. This would appear as a positive association between TFPQ and size. The figures below present a non-parametric local regression smoother (lowess) of value added rank and sector normalized log TFPQ. There is a positive association between firm size and TFPQ, while this pattern is less clear (if not negative) for TFPR. The negative, possibly flat association between TFPR and size was obtained for US manufacturing by Hsieh and Klenow (2008).

Sector TFP is obtained using a revenue weighted firm TFP average, following Hsieh and Klenow (2008). Time series variation is adjusted for aggregate output expenditures and aggregate prices, as suggested by Tybout (personal communication).

APENDIX B – Informatics industry growth: the Asian Experience.

The participation of Asian countries in global productive chains generated favorable ICT manufacturing performance, evolving from low cost (assembling) to components manufacturing and higher value added products. This was backed by local policies. Some are general across countries other are country specifics. According to Rowen et al (2007), the similarities across countries' main strategies are:

i. All Asian countries exploited lower trade barriers; reduction of telecommunication costs; lower labor costs; good infrastructure; welcoming offshoring and ousourcing by U.S., European and Japanese firms, followed by the same strategy by leading Korean, Taiwanese, etc. firms and finally the upgrading strategies of the Asian countries suppliers.
ii. All invested heavily in skilled labor with technical education, although universities did not play the role of technology providers. Research institutes were more relevant in this role.

iii. The initial developing phase was marked by the purchase of foreign technology, parts and inputs;
iv. Research institutes networks were the main source of technology for firms.

On the other hand, there were country-specific strategies (Rowen et al, 2007):

i. Korea, as well as Japan fostered entry and participation of large technology intensive indigenous firms in the ICT sector;
ii. Taiwan experienced an important role for public organizations in electronics R&D, that disseminated this knowledge to thousand of SME;
iii. Hong Kong and Singapore relied more on multinationals` FDI.
iv. Singapore´s Educational system investment allowed an upgrade on more sophisticated products such as electronic components, developing from the low level assembly as in other area countries;
v. Last but not least, China attracted foreign investment using its abundant labor, R&D capacity investment, the openness of its domestic market (local manufacturing) and general government subsidies and support.