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O ELEMENTO DE INOVAÇÃO NA LEI DE INFORMÁTICA E SEU RESULTADO

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RESUMO

A pesquisa tem o intuito de estudar a situação presente dos resultados da Lei de Informática no Brasil no que tange ao aspecto de geração de inovação das verbas de pesquisa e desenvolvimento (P&D). Com o objetivo de contextualizar a legislação, inicia-se com um breve histórico da legislação, a recente necessidade de alteração da legislação devido a decisões negativas da Organização Mundial do Comércio; e comparativos internacionais com esforços históricos de intuito similar, mas mecânica diversa, adotados por outros países. Posteriormente, em sua segunda etapa, este estudo revisa os números disponíveis relativos à Lei de Informática e os dispêndios de P&D correlatos à legislação, enfatizando importantes limitações sobre os dados que são raramente percebidos por outras análises destes números. Finalmente, foram realizadas entrevistas com diversos atores beneficiados ou de outra forma atuantes com a Lei de Informática em busca de impressões e validações de percepções sobre os dados levantados na segunda etapa. Sobre esta coletânea de dados, realiza-se uma conclusão geral do estado atual dos esforços da Lei de Informática enquanto instrumento de fomento de inovação com seus dispêndios em pesquisa e desenvolvimento. Concluímos com a identificação de sérias limitações de resultados produzidos pela lei de informática e sobre os mecanismos de monitoramento de resultados desenvolvidos ao longo dos anos.

Palavras-chave: Lei de informática, fomento inovação, desenvolvimento industrial, incentivo pesquisa e desenvolvimento.

ABSTRACT

The present research has the intent of studying the present results of the Informatics Law (IL) in Brazil as it pertains to its effect of innovation generation through its mandated R&D expenditures. With the objective of contextualizing the legislation we provide a brief historical overview of the legislation, the recent necessity of alteration of such legislation due to findings by the World Trade Organization, and a brief comparative of international efforts with similar intent, but different method, adopted by other countries. Subsequently, this study evaluates the recently available numbers related to R&D expenditures by the IL, giving special emphasis to limitations of the data that are not always perceived. Finally, we realize interviews with several participants and beneficiaries of the legislation in search of their impressions of the current situation and of our evaluation of the data generated. From this data, we make a general conclusion of the current state of the efforts of the Informatics Law in fomenting innovation through the mandated expenditure of R&D fund. We conclude with the identification of serious limitations in the results produced by the informatics law, and the mechanisms for monitoring results developed over the years.

Key word: Informatics Law, fomenting innovation, industrial development, incentivizing research and development.

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LIST DE ABREVIATIONS AND ACRONYMS

CAPES – Coordenação de Aperfeiçoamento de Pessoas de Nível Superior – Coordination for the betterment of people with higher education

IL – Informatics Law, our abbreviation for the *Lei de Informática*

IPI – *Imposto de Produtos Industriais* – Industrial Products Tax

MCTIC – Ministério da Comunicação, Tecnologia, Inovação e Comunicações

MCTI – Ministério de Comunicação, Tecnologia e Inovação

PADIS - Programa de Apoio ao Desenvolvimento Tecnológico da Indústria de Semicondutores e Displays – Program of Support and Technological Development of the Semiconductors and Display Industry

PPB - *Processo Produtivo Básico* – Basic Productive Process

SUFRAMA - Superintendência da Zona Franca de Manaus

TCU – Tribunal de Contas da União

WTO – World Trade Organization

SUMMARY

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1. Introduction

This research seeks to study the results of the innovation component of the Informatics Law (IL) currently in effect in Brazil. The IL is the already over two-decade long effort by the Brazilian government to foster a vigorous domestic electronics industry, and it also possesses a component of mandated Research and Development (R&D) expenditure whose effectiveness we seek to study.

The importance of innovation, and specially Brazil's deficiencies in innovation are a frequent matter of study such as Esteves and Feldmann (2016) who saw a too small participation of government funds in research, and others saw important elements of innovation in the Brazilian firm through acquisition and internal development behavior with financing as an important bottleneck (GOEDHUYS; VEUGELERS, 2012). Other research such as Buisseret et al. (1995) has found significant effects on increasing R&D expenditure by large companies due to government tax credits.

Our intent in this study is therefore to analyze the effectiveness of the R&D investment originated by the IL. As Clarysse et al. (2009) illustrate, an important element in considering the potential positive effect of government incentivizing R&D is the occurrence of additionality, meaning more R&D results being produced by the added resources. This is not an easy standard to analyze, as we will see, but it provides us with a guiding principle in that the actions of the incentive program should ideally be resulting in directing more funds towards R&D and not affecting the productivity of resources spent such that the output remains growing according to resources spent. We will fundamentally be trying to answer if the IL generates additionality through its R&D mandate.

Our study will proceed from a literature review of past and current Brazilian efforts, and an attempt to contextualize those efforts with a couple of international comparisons. Further, we will review the recently released data on the R&D expenditure released by the MCTIC. And finally, we interviewed a variety of companies and institutes that are benefited by the IL in order to obtain a more practical participant perspective of the current situation and uncertainties surrounding the IL affected industry.

1.1 Objective and Structure of the Dissertation

This dissertation is structured around three articles. The first article seeks to provide a brief systematic literature review in chapter 2. This article starts with a review of the literature on the Brazilian efforts to develop an innovative electronics industry. As we proceeded with the literature, we find frequent international comparisons made for clarity and contrast. We expand our analysis to comparisons of the Korean effort to the Brazilian, and finding a difference in focus. The Korean focus is export oriented while the Brazilian incentive structure seeks to foster an industry through a protected domestic market. Moreover, we find a larger participation by the great Korean industrial conglomerates (*chaebols*), while in Brazil finding the government in a much more central coordinating position. Continuing our literature review, we perceive a frequent comparison between Korea and Taiwan, and in Taiwan we see a much larger government role while maintaining the export-oriented focus. We draw from several studies in this review showing multiple paths to success in developing an electronics industry and the accompanying innovative capabilities which makes us question some fundamental assumptions of the viability of the Brazilian model of developing a high-tech capital-intensive industry and innovation capability through the protection of its domestic market for domestic producers.

Our second article reviews the available data on the R&D mandated by the IL. We seek to find inconsistencies and limitations of this data, which unfortunately we find many. Our analysis proceeds to raise several troubling indicators from the data that indicate that the mandated R&D investment might not be generating additionality in R&D results, specially troubling due to recent actions by the MCTIC that cast a cloud over past investments. While the data has too many deficiencies to allow us to reach more definitive conclusions, we find several indicators that are troubling and demonstrate the frequent changes in monitoring criteria and aggregation of the data. We seek to demonstrate both the indicators of a lack of additionality, but also the lack of a continuous and rigorous monitoring effort, which could allow for us to better target segments or instances of lower performance to improve the legislation over time.

In our third article we seek interviews with several market participants in the IL connected to R&D. This meant interviewing both companies benefited by

the IL and institutes benefited from the mandated R&D investment generated by the legislation. We find several indicators that validate our worries from the second article on the potential lack of additionality by the legislation. Namely we find two types of company profiles, those who are by their business model heavily committed to R&D and therefore greatly exceed the obligation, and those whose activities are not compatible with a heavy investment in R&D, and thus engaged in R&D they themselves believed unproductive. Both profiles suggest a lack of additionality created by the mandate in the IL. We validate several limitations of the data we found in the preceding article, but also raise elements that are found in the aggregate data that do not apply to the reality of any company or institute interviewed.

We avoid a prescriptive conclusion to the legislation since the main perception is one of lack of data and continuous analysis. We identify clear points where the data can be improved, and most importantly, be continuously gathered over time in a comparative fashion; but we must stress that our main conclusion is that, despite the long period the IL has been in effect, the capacity of research to objectively analyze its results is severely limited.

1.1.2 Limitations

We seek to contextualize the efforts of the IL as it pertains to its innovation and R&D component, we will not undertake a deep analysis of the component of industrial policy in the legislation. Namely, we will not seek to evaluate the policy as it pertains to fostering industrial development, focusing on its innovation component instead. While we make a brief exception to this limitation in our first article, it is meant only to expand the pool of available research to study and draw general inferences about the fundamental structure of the IL while in an international context.

From a temporal perspective, we seek to study the IL legislation from its beginning in 1991 until the present. Unfortunately, the data from the initial 15 years of the legislation has greater deficiencies, which encouraged us focus more intently on the years following 2006. Therefore, while we will address the entire period, we will naturally tend to favor in focusing our analysis the period that we have more substantial data.

Naturally the perception of results from R&D can be an elusive quest, which is why we attempt to center our analysis on the limited quantitative data set developed over the years by the MCTIC. On our first article we will drawn some comparatives with different policies implemented on other countries. Such comparisons are meant only to highlight differences in methodology between the countries and the Brazilian effort, and not as an exhaustive analysis of the industrial policy across several countries.

1.2 On the Current Legislation

We will review in detail elements of the legislation in individual subsequent sections, but a brief overview is appropriate. The IL provides several tax benefits for firms and products that can classify and seek such fiscal treatment. The scope of the benefit is such that it is highly required for a competitive presence in the Brazilian electronics market as we will also see subsequently.

The IL provides its fiscal benefit to firms that agree to follow a particular production process, named in the legislation *Processo Produtivo Básico* (PPB) – which can be translated as Basic Production Process. This is composed of a particular description of which industrial processes must be conducted within Brazilian territory in order for the fiscal benefit to be merited. All this is naturally a very complex procedure that involves multiple ministries of the federal government, but is mostly monitored by the Ministry of Science, Technology, Innovation and Communication (MCTIC for the Portuguese acronym).

Other than adherence to the PPB, the IL requires that a percentage of the revenue generated by incentivized products be spent on research and development projects (R&D) also within the Brazilian territory. The legislation further requires that a percentage of this obligation be spent on non-profit institutes or universities outside of the company. Over time the legislation also required that different percentages of this same R&D be spent on public and private non-profit organization and that a different segment of these resources be spent on non-profits located in the, considered, underdeveloped North or Northeast region of Brazil. We will review these details in their appropriate sections, but as we can see it can quickly become a complex obligation. The results of these expenditures must be reported to the MCTIC annually for

compliance with the legislation. It is the effectiveness and results of these expenditures that we focus our primary interest in this research.

There are several other legislative efforts in Brazil that are somewhat connected to IL mechanisms but that are distinct and not a subject of our study. Taking two examples: i) the industrial region of the Amazon has even more significant fiscal benefit, also uses the similar PPB mechanic and R&D obligation in its scope, ii) also the *Lei do Bem* provides a fiscal incentive as an income tax credit for R&D investment and further tax reduction. The first example is similar in mechanism, but is not only exclusively applicable to the same type of products, and also has a completely different legislative underpinning. The second example is frequently used by any company that operates in R&D, and should be seen as complementary to the actions of the IL.

We considered including a study of the Amazon region R&D as a contrast to the nationally based IL R&D obligation. Unfortunately, while we will face many challenges with data in our IL study, for the Amazon region the reporting organization is the *Superintendência da Zona Franca de Manaus* (SUFRAMA), that unlike the MCTIC has not published any relevant data on the R&D expenditures, preventing such comparison for being fruitfully made. As we will see subsequently, from the IL we do have recently released data by the MCTIC.

1.3 The Challenge Posed by the World Trade Organization (WTO)

The framework of the IL incentive has created a powerful mechanism that affects several products, but as we will subsequently see it has a large reach in general consumer electronics. The nature of the legislation creates a very favorable situation for the products that are benefited by the IL in the domestic Brazilian market. As a result, the legislation has been subject of criticism as a violation of the World Trade Organization (WTO) rules that prohibit different fiscal treatments solely due to the national origin of a good. There were complaints made in the WTO by both Japan and the European Union that were later joined into the same arbitration proceeding.

On August 30th 2017 it was made public the WTO panel analyzing several Brazilian incentive programs including the informatics law (which the WTO names the collective of laws around it as the Informatics Programme). The conclusion of the panel has been entirely negative towards the position held by the Brazilian Program finding all the incentive laws in question, including the informatics law, as in violation of WTO rules (WTO Panel Report, 2017).

The decision by the WTO will probably be of difficult resolution for Brazil, since the analysis by the panel found the core elements of the legislation in Brazil is in violation of WTO rules. Fundamentally, the different tax treatment afforded to a product manufactured in Brazil as opposed to an imported product is a fundamental violation of the WTO rules (WTO Panel Report 2017, p.97-102, p. 139). This position not only places in jeopardy the Informatics Law, but similar programs such as the *Lei do Bem* (directly related to a reduction of taxes towards nationally developed goods), the PADIS program (directed at the semiconductor industry), and other programs[1].

As a result, it was the core mechanic of the legislation that has been found illegal and it will probably have to be radically changed in order to avoid allowing retaliatory measures by other WTO members. Therefore, Brazil finds itself in the position of having to radically change the fiscal framework that is the cornerstone of its electronics industry and a significant source of R&D funds for public and private institutions. As we will see in chapter IV there are substantial information deficits around the status and results of the current legislation, and in which such decisions will have to take place[2].

It is important to note that the WTO Panel made clear that other forms of subsidies exclusively to their domestic producers are allowed by WTO rules, and even larger special dispensations are allowed to developing countries, what was a violation was that instead of incentivizing producers, the products themselves

[1] The full list of programs analyzed and found in violation of WTO rules see the Panel summary decision (WTO Panel Report, 2017 p.28-33).

[2] It should also be pointed out that the foundation of using the PPB to obligate the purchase of domestic components is fundamentally threatened by the decision, which also

were being treated distinctly in the added-value taxation. To quote specifically from the panel's decision (WTO Panel Report, 2017, p. 170):

> 7.501. The Panel would like to clarify that it has concluded that the subsidies at issue are prohibited because, based on the specific facts of this dispute, these subsidies are contingent upon the use of domestic over imported goods. However, the Panel is not saying with this that Brazil, or any other WTO Member, is not allowed to grant subsidies exclusively to their domestic producers with the aim of fostering the development of their industries.

Subsequently, in December 2018 the WTO Appellate Report sustained the initial panel decision, but created a more flexible and non-specific timeline for Brazil to comply to its decision – the usual timeframe is 90 days. Nevertheless, it cements the need for at least profound changes in an already long-standing legislation. This places a severe emphasis on the need for data to allow for and data-driven intelligent policy consideration in order to find ways to change the long-standing legislation and achieve developmental goals.

2 - An Exploratory Essay on Government Incentivized Innovation in the Modern Electronics Industry: the Brazilian case compared to the Korean and Taiwanese Experience

Abstract: Intent on contextualizing the theoretical and practical elements surrounding the applications of state action to foster innovation and innovative economic sectors within the electronics industry. Reviewing academic literature on the policy implemented both by Brazil and a select group of nations with particularly successful programs we seek common elements to success and failure to guide future endeavors. We find multiple viable development paths in export-based industry, and Brazil seeking a hybrid methodology with a focus on a domestic market import-substitution strategy finding much more limited success.

Keywords: Innovation, government-incentive, Brazil, Korea, Taiwan, and Electronics Industry.

2.1 Introduction

Innovation has been seen as a relevant factor for generating value and profits for a considerable time. Schumpeter (1934) perceived the importance of innovation in value creation, and also expanding its concept to include organizational and technical elements that transcended the limited definition of an invention as a new object. As the tempo of innovation increases the study of its impact and relevance also advances and new forms of promoting innovation are attempted and studied.

As more complex studies of innovation proceeded, the discussion came to be expanded into the role of what is perceived as national systems of innovation: a concept where the interplay of several regional and national diverse elements affects a country's capability towards innovation. These are concepts who go back as far as List (1842), but were given their more modern interpretation in Lundvall (1992) and Nelson (1993). As Freeman (1995) and Edquist (1997) illustrate with a wide variety of examples and frameworks, the concept that regional aspects and interplay between educational systems, legal framework,

trade relations, cultural trends and other factors are all relevant and in effect create a unique national system of innovation. Each individual system is more or less apt to innovate in a particular way. This naturally expands immeasurably the potential field of study, which also forces us to approach it in a methodological limited way and always conscious of the inherent flaws and limitations of our chosen approach.

In such complex system many proposed frameworks of study have been proposed, Etzkowitz and Leydesdorff (2000) trace several schemas and emphasize the "Triple Helix" framework where industry, government and university interplay takes a central focus. We can specially perceive this interplay when governments take active measures towards fostering a particular economic sector. As governments took notice of the value of innovation and its interplay with innovation systems, it became natural for governments to attempt to foster more robust innovation system in their developmental programs. Given the vast possible complexity of the subject, it is natural that any academic approach will tend towards specialization. We will focus on a particular program in Brazil called the Informatics Law (IL) that seeks to develop the electronics industry and sectorial innovation through an intentional fostered interplay between government, industry and universities.

In this paper we focus on the government's efforts to foster innovation in the electronics industry, contrasting the Brazilian example, with its current legislation, with Korean and Taiwanese experiences of similar time-frame but very different results. The reason to choose these two comparative cases is that there is a substantial literature comparing them over the period in question (more specially Korea and Brazil, and Korea and Taiwan, with far fewer examples of studies between Taiwan and Brazil). Adopting an exploratory approach, we review literature on the topic in order to identify common elements to success and failure to guide future endeavors.

This approach has substantial relevance as the government's role in innovation has frequently seen as considerable and relevant in the fostering of innovation. Economists from several backgrounds such as Nelson (1959) and Arrow (1962) point to government policies as a method in correcting potential

market failures that lead to situations of suboptimal investment in research. Grossman and Helpman (1991) also saw positive results in government fostering of innovation for increasing the overall amount of spent resources on innovation. More recently the argument defending the government's critical role in promoting the most daring and economically risky segments of innovation has been forwarded by economists such as Mazzucatto (2018) in perceiving that only governments would have the funds and capacity for long term investment needed for some truly transformative innovative endeavors. The type, scope and scale of governmental efforts to foster innovation can take many forms, but even in direct contribution they are already a very considerable element as can be seen in studies such as of Thomsen and Jansen (2003) that found that among OECD members government funds approximately 30% of private companies' R&D expenses, making them an important element of study. Other, more econometric approaches also found benefits, such as Minniti and Venturini (2017), who have found positive correlation in an analysis of the US manufacturing industries between an increase in R&D tax credit and increased labor productivity.

2.2 Methodology

We proceeded to familiarize ourselves with the literature in the subject by the way of a systematic literature review. Thus, we adopted a reproducible process of producing an article search, restricting for journal articles, analyzing the titles for appropriate relevance. Those articles selected as appropriate from their titles would have their abstract read, and if found relevant to our subject the article itself would be thoroughly studied. This would allow for a systematic way of guiding our research. A systematic literature review is based on a structured and ordered process of identification, selection and study of previous published research. We followed the four-step process also used by Medeiros et al. (2014) and Tranfield et al. (2003), namely research the problem and keyword definition, selection of published studies, the evaluation of the studies, and the synthesis of the selected studies.

Beginning with a research in the Science Direct academic database using the keywords "informatics law Brazil" we found 663 results, of those after the analysis of title we proceeded to read the abstract of 17 articles, and found from the articles that 9 of those were pertinent for our study. A new search of the

Portuguese terms in Science Direct "*lei de informática*" produced 127 results, but from those only three were found to have titles that indicated relevance, and from those after the abstract only one was pertinent to our search.

Expanding our research criteria, we performed a new search on Science Direct (always restricting to journal articles) for the keywords "policy development electronics industry Brazil" that produced 2,108 results. From those, 89 had relevant titles, of which we found after the study of the abstracts that 35 were relevant to our study due to them covering the specific Brazilian electronic development policies relevant to our study.

Our search at this point found the frequent practice of multiple country comparison as a form of study. We found frequent comparisons across time between Brazilian and Korean efforts, as interestingly distinct going from the late 1980s to the mid-1990s. We expanded our research in Science Direct than to "policy development electronics industry Korea", which resulted in 3,417 papers, of those the titles of 165 were found have keywords and research context related to our research interest and after a study of their abstracts we found 63 of them as relevant for further study due to them relating to the subject and time-frame relevant to our research.

We found ourselves interested in a greater sample of domestic Brazilian studies, and proceeded to research the ScieLo database searching for "*lei de informática*" and finding 8 results, only one of which was relevant both in their title and abstract for our studies. A new search for "*indústria eletrônica*" resulted in 133 results, of which the titles of 9 were found relevant and 4 were studied after the abstract was found to be related to our study.

Disappointed with the amount of research published in Portuguese being located, we expanded our search for the CAPES database of thesis and dissertations using "Lei de Informática" as the keywords, and found 28 results, eight of which have relevant titles, and we retained 5 of them after analyzing the abstracts. We also expanded to the Lume database of academic works published in the *Universidade Federal do Rio Grande do Sul* (UFRGS). Restricting our search for graduate studies, we searched for "lei de informática" and found 1,166

results, of which 76 had relevant titles, after a study of abstracts we retained 32 of them.

We have also selectively relied on the sources and references of the studies that have been retained for full appraisal when we found their contextualized use relevant sources by them, specially to avoid indirect citation whenever possible. This expanded our sources outside of journal articles also adding books and sector studies by public entities such as the *Banco Nacional de Desenvolvimento Economico e Social* (BNDES).

Our research found a frequent pattern of comparison of different countries as contrasting mechanism to explain and contextualize development efforts being undertaken. We found a considerable amount of material comparing the efforts of Brazil and Korean, and comparing the Korean to Taiwanese efforts of developing their electronics industry. We choose to provide a brief overview of these characterizations as we found the technique illustrative.

Naturally such a broad topic doesn't allow for simplistic solutions, our intent is not to provide a definitive path to developmental success (or even suggest that such an undisputed path exists), but to contextualize previous and current efforts into their own past and our current perception of such efforts. As Brazil will most likely face a revamping of its currently nearly 30-year policy in the IL, the importance of a syncretic overview is increased for the discussions to follow.

2.3 On the Inherent Issue of Additionality

A frequent point of debate regarding government efforts to foster innovation is whether the effort is promoting effects of additionality in inputs or outputs. The concept is well introduced by Busseret et al. (1995) on whether direct extra funds being made available to companies expanded their investment portfolio or merely financed investments they would otherwise perform. Although definitive answers are difficult – and his initial analysis was primed towards direct subsidies rather than other formats such as tax credits, he proposed a framework for analyzing the occurrence or not of additionality that could take place in inputs (effectively raising the amount invested) and outputs (producing more results). Busseret et al. (1995) also introduced the concept that government efforts to foster innovation could also have behavioral effects, and as such alter in a long-

term fashion the choices of the affected firms due to exposure to an incentive structure.

Naturally, this is not a proposition that permits itself simple testing as it contains in itself the comparison with an unrealized alternative. A considerable focus is placed on whether the incentive structure created additionality in inputs, see Georghiou (1999), Davenport et al. (1998), and Georghiou et al. (2004). As Clarysse et al. (2009) demonstrate, the emphasis on input additionality is frequently trying to determine if there occurred a crowding-out effect, either by introducing inefficiencies that raise the R&D cost, or simply fund with public resources R&D that would have taken place anyway. Research by Duguet (2004), Czarnitzki and Licht (2005), and Gonzalez and Pazo (2008) has found no evidence of significant crowding out effects in their analysis (in these cases of French, Germany, and Spanish incentive structures respectively), but this should not be taken as a case that the occurrence of such crowding out is disproven to take place in all cases.

Clarysse et al. (2009) mention how output analysis tends to be a preference by legislative bodies trying to ascertain some form of cost benefit equation for the incentive provided. Frequent outputs used in such metrics are patents and publications generated, but all recognize the difficulty of generating robust results from such data. The very concept of outputs can be made increasingly complex by output additionalities such as revenues of new products and other factors. Kettle et al. (2000) have attempted a microeconomic analysis of outputs from studies of several countries, specifically avoiding more qualitative outputs such as interviews. They find that the studies frequently conclude with conclusions of output additionality but Kettle et al. (2000) find several restrictions with the results obtained.

Knowing of such limitations in evaluating single programs, it is not our intent to provide a comprehensive and definitive analysis of three national programs in a single paper. Our objective is to contextualize these efforts and the current understanding of their successes and limitations.

2.4 Brazil's Previous Effort of Market Reserve

Brazil has a substantially long history of legislation specifically design to foster its electronics and information technology industry. From a period of a more pronounced and explicit market closure created by the National Informatics Plan in 1984 that essentially created a market reserve for domestic companies in the informatics sector that was followed by a reversal of strategy towards a more open market with the introduction of the IL in 1991.

A review of the results and efforts that the legislation preceding the LI produced can be found in Schimitz and Cassiolato (1992), who found significant (if incipient) development of an electronics and automation industry, placing special focus on the successes of the banking automation sector. While they identify an incipient component industry, they emphasize its lack of scale and the development of generally older technologies than the ones being used elsewhere in the world. A recommended overview of the electronics industry between the previous legislation and the first decade of the IL can be found in Cassiolato (2003), where we find a high rate of industry closure on the transition from the closed market to the more open incentivized paradigm created by the IL in 1991. This is also perceived by Tigre and Antonio (2001), who trace important parallels to the new legislation with the stability and potential for foreign direct investment (FDI) for the development of what it calls the IT sector as to be incentivized by the IL. Others that reviewed this transition period were Meyer-Stamer (1992). Nevertheless, they are apt in pointing out that the change from market reserve towards a more liberalized policy meant the end of virtually all Brazilian owned hardware firms developed during the market reserve period of the preceding law; and while remnants of the past development are still present a substantial part of what was created in the previous effort could not survive the transition to the new model of incentive and more liberal market participation ushered by the IL.

2.5 The Informatics Law

The triple foci of the new legislation were to (i) create a profitable industry with a competitiveness in the domestic market, (ii) finance new innovation, and (iii) generate capabilities among the Brazilian workforce with the newer technologies being developed for production in electronics.

The legislation suffered minor alterations to its format, mainly removing some elements from the income tax benefit, and shifting the incentive towards a deduction in the industrialized products tax (named IPI). There are other minor advantages in import taxes, but the IPI tax is of a considerable percentage in Brazil, and the discount goes from 80% to 100% of the rate depending on characteristics of the good being produced – it is hard to compete domestically without such a discount achieving the objective of creating competitiveness for companies that produce domestically in Brazil. Nevertheless, it is an entirely domestic market effect, as such taxes are not applicable to export operations. Therefore, the current scope of the IL generates a greater competitiveness for participants in the domestic Brazilian market when compared to foreign alternatives. The numbers produced for exports on the IL benefited companies remain considerably small (Prochnik et al., 2015). As the focus of interest remains the viability and profitability within the domestic market, the management perception of viability and profitability of the risks inherent in foreign operations will remain subdued. As Moon and Lee (1990) have noted in an analysis of the Korean export industry, the perception by the management of the strategic importance of export operations is crucial for the development of a vibrant export industry – it is a new and risky challenge which require a special focus (and preconditions) to succeed.

The element of financing innovation of the legislation comes from an obligation to invest five percent of the gross revenue that is incentivized by the LI into R&D. The legislation has the requirement of dispersion of funds across institutes, universities, and other acceptable organizations across Brazil. The composition of the division of these funds has changes slightly over time that the legislation has been in effect, but it requires a division of funds across public and private institutions and a fraction to be invested in such institutions in the North and Northeast of Brazil, whereas the largest quantity of companies benefited by the IL is in the Southwest. In general, this has been an ambitious format that sought to generate greater integration between the private sector and universities while creating and funding independent institutes and fostering the development of science and research institutions in the North and Northeast regions. The quality of this effect is very hard to measure. There is a body of research that

considers a growing scale of the institutes' funding as a measure of partial success, such as Balbachevsky and Botelho (2011) who make an extensive study of the framework of innovation they perceive as partly created and funded by the IL law. Others (e.g., Mazzoleni and Nelson, 2007) view the degree of growth in scale of diminished importance when actual university and institute participation is compared to some other countries' efforts.

From a productive technology standpoint, Ribeiro et al. (2011) have found that the Brazilian electronics industry kept apart from the global value chain, as it accessed external suppliers for elements of technology but merely to apply and supply them in the domestic market and that such characteristic has dramatically limited the effects of the law. A similar conclusion was previously reached by Mazzoneli and Nelson (2007), in contrasting Brazil to Asian examples:

> An interesting contrast to the cases of Korea and Taiwan is provided by the Brazilian experience. Here too, policy makers have long recognized in words if not in fact the importance of indigenous scientific and technological capabilities toward national economic development. However, the record of accumulation of technological capabilities across the spectrum of industrial sectors in Brazil has been considerably less impressive than those of Korea, Taiwan or Japan (Mazzoleni and Nelson, 2007, p. 1522).

Mazzoneli and Nelson (2007) are careful to mention that Brazil has had success in efficiency and integration of its industry with its academic ecosystem, highlighting commercial aviation and the case of the success of Embraer as a particular example, indicating that some specific elements of the informatics ecosystem are obtaining subpar results. Others have sought output statistics such as patent applications by universities, finding in their growth a proxy indicator for success. As we saw above, confirming actual additionality by output measures is considerably tricky, and studies of how patent applications by universities can be an indicator of a growth in their participation innovation such as Fischer, Schaeffer, and Vonortas (2018), do not consider the sentiment perceived in private companies of the low practical viability of seeking patent protection in Brazil due to the time lag between the patent application and it being granted (see chapter 4.0)

As time passed, substantial changes have taken place since Albuquerque (1999) characterized the Brazilian innovation system as a whole as immature, but

perceived the recent past as one of moderate progress. MCTIC data itself shows a considerable growth in revenue in companies benefited by the legislation, particularly in areas of personal computers and cellphones (see chapter 3.0)

While controversial in its verve, negative conclusions as to the success of the current legislation has been voiced by others and is preceded even by the MCTIC (then named MCT) in its evaluation in 1999. As we quote from Souza (2011, p. 28):

> At the end of the 90s, the Informatics Law went through its first evaluation. The results from the MCT report already identified the importance of correcting certain elements of the policy. For example, the text already mentions that "the priority must fall to software, (…) that became the main driver of innovation" (p. 25). In its conclusions, the report recommended to: develop actions to attract global component manufacturers, review discrepancies in importation taxes that worked against the production of electronic components, and make the PPB more flexible so that it would also encompass service and software activities. Although the diagnostic was precise, few of these propositions were incorporated into the subsequent revisions of the legislation after this evaluation.

Several authors such as Villaschi (2005), Batista (2010), and Sergio and Porto (2012) are quite critical of the results of the current legislation. Highlighting both the opportunity cost that potentially more expensive electronics have in the overall economy create cascading inefficiencies, as well a general failure to foster an industry that is competitive internationally or even domestically viable without the continuation of the incentive program. Several participants such as the class organization ABINEE (the national association of electronic manufactures) have published a wide range of statistics of revenue growth and jobs created by the sector, however their publications rely on the MCTIC data that we will review in chapter 3.0 (ABINEE Cartilha)

2.6 PPB as a Driver of Industry

The PPB (*Processo Produtivo Básico* – Basic Production Process) is a mechanism by which the IL strives to guide the production it incentivizes towards a denser supply chain and hence slowly create more suppliers for components and more basic non-consumer products for electronics. Authors such as Sergio and Porto (2012), Araujo (2010), Souza (2011), and Prochnik (2015) in general

see this element as a failure, as no significant competitive components industry has emerged in Brazil in this time period.

Sergio and Porto (2012) have noted how the current structure of the LI creates a dichotomy in that the legislation is attempting to confer competitiveness to the industry with tax incentives, while trying to finance innovation from the margin of what is essentially a low aggregate value electronics industrial operation, while also burdening it with inefficient costs attempting to jump start other sectors of the electronics supply chain. In their view, this complexity in attempting to stimulate the competitiveness of the industry while at the same time directing the surplus of such activities results in (predominantly) inefficient producers for the export market that perpetually require the incentives to continue operations in the domestic market.

As Souza (2011) points out, the continuous changes to the PPB have favored the introduction of low-level assembly requirements as the crucial requirement for classification as a product eligible for the benefits of the IL, favoring elements such as the assembly and soldering of components on circuit boards that were a crucial and most sophisticated requirement on the very first PPBs in 1991, and were still the crucial technological requirement on the newest PPB released by the time of the paper by Souza (2011). The current PPBs being released such as for onboard computers for non-automotive vehicles in the *portaria interministerial* MDIC/MCTIC nº65 from December 6th 2018 still places the crucial technical requirement as soldering of the components on the circuit board (BRAZIL Portaria 55). We can see then that in over twenty-seven years that the legislation has been in effect, it has not added significant new industrial steps upscale on the technology frontier for the PPBs.

There is a focus, then and now, on the PPB to mandate plastic molding and injection, metal work, and general electronic assembly to be performed within the borders of Brazil. Taking as an example the portaria nº 65 above (Portaria A), it specifically exempts from the necessity of performing inside Brazil the assembly of LCD (Liquid Crystal Display), GPS (Global Positioning System), and communication modules. All of the preceding are not precisely new technologies

in all their implementations, and yet were carved out of the PPB in the negotiations between industry, the MCTIC and MDIC.

As Prochnik et al. (2015) have commented, the nature of the process of PPB change can be summarized as being led by the government, but negotiated with companies in such a way that only economically viable alterations were to be made. As a result, any domestic component had to produce considerable savings compared to the larger providers in Asia since they would represent a cost in "breaking the kit" – meaning not buying the bundle of necessary electronics components from an aggregator and having it shipped in a different logistic schema than the other components. As a result, any newly developed Brazilian component supplier would have not only inefficiencies of scale when compared to global suppliers, but would also face logistical costs as their product could not be bundled in Asia in a kit ready for assembly as is current industry practice.

We can then perceive that the PPBs were not in effect used as mechanism to drive innovation forward, and have basically preserved a simple exchange, namely the assembly and soldering of the components onto the circuit board as the core of the industrial exchange for the obtainment of the fiscal benefit. It can be argued that the benefit therefore is of job creation and not of fostering industrial innovation, but it is also a fact that ever smaller components have led into greater and greater automation of the electronics assembly process reducing the long-term potential for job creation in this activity.

2.7 On Contrast with Korea and Taiwan

The reason to choose Korea and Taiwan as comparison points require explanation. While all nations follow their own individual path of difficult replicability, Korea and Brazil were frequently compared in their efforts in the beginning of the electronics industry. As the results of the Korean and Taiwanese policy proved ever more successful in comparison to the Brazilian experience the frequency of such comparisons declined. Regardless, as noted by Etzkowitz and Brissola (1999, p. 338), the expectation that one particular policy (in this case Korea and Brazil) would have been wildly more successful than the other was not always clear:

> Korea and Brazil's positions in the international economic order have been reversed since the early 1980s but it was not following market rather than interventionist models that made the difference. The two countries had interventionist policies but of a different stripe, with Brazil concentrating on developing internal markets and South Korea on exportation.

Evan and Tigre (1989) make an extensive comparison between the Korean and Brazilian situation in developing their electronics industries. In their comparison they note that in the preceding decade of the 80s Brazil outpace Korea in several instances in penetration of computers across the industry. But they also point to elements of differences which we will see replicated in later periods. As early as the late 1980s Tigre and Evans (1989, p. 38) are quoted saying:

> The Korean success in personal computers is unlikely to be repeated in Brazil, due to the lack of competitiveness of the consumer electronics sector…. The truly Brazilian manufacturers started to export in 1983, focusing on niche products such as commercial automation.

Therefore, despite the decades of the IL in effect the current reality is similarly described by Sergio and Porto (2012). It places the path in which the Korean industry prospered while the IL preserved a similar situation in Brazil particularly relevant, despite the fact that the scale of the Korean success makes the comparison between the two industries in their current form far less illustrative. It is a case of studying by what trajectory similar (but distinct) starting points produced wildly different results.

The Taiwanese comparison is rarer in the case of Brazil, where the analyses conducted, such as Hauser et al. (2007) tend to compare with the mainland Chinese with the Brazilian experience marking a wide variety of differences in starting points and strategic choices. The Taiwanese comparison in this paper is most useful as a comparison to the Korean experience. Where Taiwan and Korea are frequently compared in the literature, they followed from relatively similar starting points towards great success. However, they followed very different strategies and, naturally, arrived at successful but distinct results. Therefore, they become a good point comparison between themselves and the Brazilian experience, whereas comparisons between Brazil and the People's Republic of China can be made we found this triple comparison more illuminating.

2.8 A Brief Narrative of the Korean Example

The narrative of the electronics industry in Korea is one of developmental success. The country went through a period of negligible role in electronics in the 60s to be in the 21st century a leading nation not only in the manufacture of electronic products but on the development of new technologies and home of companies that are lead innovators in the sector (Chung 2002).

When studying the history of Korean chaebol success, we must be impressed by the dominance of the larger players in the industry scope. Even before the Asian Crisis, as noted by Bloom (1993), Samsung and Goldstar groups were responsible for 45% of the Korean electronics and telecommunication production, and over half of the research personnel in these sectors. The LI in Brazil has generated a large number of small and innovative companies, but very few large organizations as we noted in the interviews in chapter 3 – interviews and as the MCTIC data shows (See chapter 3 and 4).

Nevertheless, it is not all subject to *dirigisme*, as Bloom (1993) notes the regional ecosystem and the success of and strategic decisions of American and (specially) Japanese investment strategies generated substantial unique technological transfers and financed early production in the Korean case. Quoting Bloom (1993, p. 127):

> By 1976, over half of all employment in the Korean electronics industry was in foreign-owned or joint-venture companies. Since then, the balance has shifted markedly towards domestic firms, particularly Samsung and Goldstar, as the latter's export strategies began to succeed. This was accompanied by withdrawals by Japanese companies, especially in the 1980s.7 As a result, employment in wholly-owned foreign subsidiaries declined by a third between 1976 and 1985, despite employment in the industry as a whole growing by almost 50 per cent, while their share in Korean electronics exports fell from around 55 per cent in 1972 to below 40 per cent in 1980. Electronics components and parts remain the one area where foreign companies still predominate, accounting as they do for almost 60 per cent of total components production, mostly through joint-ventures.

Bloom (1993) and Castley (1998) show the Korean example of an early use of a competitive advantage in a cheaper labor force provided merely an initial impulse, allowing them to increase operations supplying both the Japanese and American markets with additional foreign capital investment. Later efforts, which involved international expansion of Korean corporations with a technological strategic objective, the presence of fractured and undercapitalized segments of

electronics in the United States, permitted a strategic plan for acquisitions. These acquisitions allowed for successful technological absorption strategies allowed by the mid-80s for Korea to begin exporting more advanced products, and have advanced its industry to the point of moving its production stages of low aggregate value to other south Asian countries, such as Malaysia and the Philippines.

This reprioritization against selling cheaper labor for assembly was later accelerated, as NAFTA allowed Mexico to become a prime supplier to the US market of several consumer electronics products. This pattern was also identified by Yun (1987) perceiving the defensive nature of what he terms “reverse foreign direct investment” by Korean firms seeking to invest internationally in technology acquisition in order to seek protection in its export market as it risks losing competitiveness to new entrants in low cost products.

The Korean industry trajectory is marked by the large industry consortiums called *chaebols*. Pucik and Lim (2001) demonstrate with a detailed view of Samsung’s history the elements of initial industrial protection (prior to the 70s) allowed for the creation of companies supplying the domestic market that then consolidated into chaebols to seek competitiveness for the international market. Sato (1997) also describes how Korean chaebols consolidate seeking technological robustness to have its own technical specifications seeking efficiency for the international market, first for televisions and later for more sophisticated products. More importantly, the drive for exports and competitiveness was preserved by the government in demanding export ratios of production and preventing companies from staying in the domestic markets where higher profits could be obtained (Sato, 1997; Bloom, 1992). It is also an important and common element of chaebols to be strongly diversified groups, and as the business cycle favored one or another industry the chaebol as a whole could cross-subsidy itself in periods of difficulties for a particular sector; this was especially important to preserve long-term R&D investment as noted by Bloom (1992).

The R&D cooperation is a feature, not a panacea. Sakakibara and Cho (2002) show how Korean cooperation on R&D was actually inferior to the

Japanese practice of corporate cooperation in such endeavors, while still producing robust results. The quality of the R&D applied by the Korean industry cannot be overstated, as Sato (1997) reminds that initially with no options for technology acquisition Korean companies devised several indigenous solutions in order to continue as competitive suppliers. Once this road became insufficient as the pace of progress increased the Koreas shifted strategies in 80s and 90s to acquisitions of companies for their technology in the American market.

The iterative nature of the strategic position must be stressed. As Mathews (1998) notes the Korean crisis of 1997 imposed several changes to financial, organization and philosophical stances by the Korean government and industry. Changes that forced a greater flexibility by the larger chaebols who were by then preserving businesses that should be closed and generally increase efficiency and transparency across the corporate and financial sector. Nevertheless, Mathews (1998) and Chang (2003) show how such changes were adopted and allowed for a quickly refashioned, more financially open and transparent structure to emerge and continue to prosper. As Change (2003) illustrates, the abandonment of the cross-subsidy system in certain sector, the government distancing itself and allowing chaebols to fail, and the incremental transparency and efficiency of the system were hallmarks of changing the previous strategy whose time had ended. Therefore, the predicate should not be the establishment and pursuit of a merely consistent apt policy across decades, but to have the managerial and government flexibility to change with the times.

As Chung (2002) stresses, even after what would (from the Brazilian perspective) be seen as a wildly successful policy of fostering innovation and industry, regional discrepancies in development are still a matter of study and potential improvement:

> First, as of the end of 1999, there are 4731 innovation actors in Korea. It means that each region has about 300 research institutes on average. The Seoul metropolis has the most innovation actors, with 1673 research institutes (35%). Kyonggi (1139 institutes) and Inchon (252 institutes) follow Seoul in the total number of research institutes, (Chung, 2002, p. 78).

When we are faced with such need for adaptability, the length of the current format of the LI when compared its intended results with its effective

results gives us pause and wonder if a change of course wasn't necessary prior to the WTO decision requiring Brazil to change or abolish the IL. The greater capacity to adapt comes from frequent assessments of our current situation, another example of where the Koreans excel, as can be seen in Lee, Son and Lee (1996), a combination of studies of outputs, inputs and processes evaluated the aptness of indicators being used by several companies. As we will see in subsequent chapters, the Brazilian government has significantly abdicated the monitoring of the R&D results of the IL (see chapter 3).

2.9 A (very) Brief Narrative of the Taiwanese case

The Taiwanese example is illustrative and an apt comparison of a different strategy than followed by Korea or Brazil in their strategies to develop an advanced electronics industry. As Nagano (2006) shows, both Korea and Taiwan started from a similar situation in the 1960s, followed aggressive export-oriented industrializations in the electronics sectors in the 1970s, and became major exporter of finished electronics products. However, in the 80s their core strategies seem to diverge strongly, with Taiwan's government taking a more direct role and the absence of the large chaebols present in Korea.

While Taiwan was known for its low-cost electronic assembly, the government would take a larger role than the Korean example due to the absence of the chaebols. As Sato (1997) indicated, Taiwanese companies tended to be of small and medium size and thus government initiatives took center stage. Early efforts could be seen in 1973 when it founded the Industrial Technology Research Institute (ITRI) in order to bear the burden of research and training personnel that the private sector could benefit from (Mathews, 1997).

The lack of chaebols made the government efforts to foster innovation more relevant, perhaps the most important of those was the foundation of Hsinchu Science Based Industrialized Park in 1980 to incentivize and foster technology transfer for the smaller Taiwanese companies to be able to remain competitive and export oriented (Sato 1997, Nagano 2006). As Lee and Yang (2000) illustrates this park along with ITRI would be the initial employer of several future founders of companies in the electronics sector, including the Taiwan Semiconductor Manufacturing Company (TSMC). The Hsinchu Park meant not

only the creation of a cluster of firms and talent, it also meant proximity to two national universities, easier access to public R&D expenditures, and preferential treatment in government financed initiatives.

Nagano (2006, p. 655) illustrates with a particular statistic quite well how government policies supplant the chaebols in Taiwan:

> Reflecting the Korean government's R&D policy, which centered on chaebols, total R&D expenditure of the top six chaebol electronics firms, i.e., Samsung Electronics, LG Electronics, LG Electron, Hyundai Electronics, Daewoo Electronics, and Daewoo Communications, accounted for 30% of the total R&D expenditure of Korean manufacturing firms in 1993. On the other hand, in Taiwan, where the National Science Council initiated R&D investment, public R&D expenditure accounted for 52.2% of total domestic R&D expenditure in 1992.

Mazzoleni and Nelson (2007) find equally compelling statistics in the fact that by 1987 private sector R&D accounted for 80% of the national R&D funding in Korea but only 40% of the total in Taiwan. Ertzowitz and Brisolla (1999, p. 339) also conclude with a similar point:

> Taiwan, on the other hand, depended more on fiscal incentives, administered selectively to promote specific industrial priorities. Public companies in Taiwan played a much larger role in the development of fixed capital than in Korea.

The amount of capital invested in R&D in Taiwan is so considerable and it increases from 1.75% of GDP in 1993 to 2.16% of GDP in 2001 (Hsu et al., 2009). Although Taiwan lacked the Korean government's effort for conglomerates, the capacity for government coordinated effort of smaller companies and educational institutions allowed for Taiwan to be a considerable player in electronics and specially semiconductors through a different strategy than Korea as noted by Mody (1990). The capacity to innovate in sophisticated electronic fields with smaller companies is also a very Taiwanese characteristic as shown by Yang and Huang (2005).

The trajectory of a successful Taiwanese electronics industry continues after this period, but it becomes increasingly attached to the progress of mainland China in electronics from where Taiwan ends up becoming both a source of know-how and a bridge for foreign capital intent on investing in mainland China (Hu; Hsu, 2010). The success of this strategy can be seen on the Taiwanese continuous role in electronics and semiconductors, but becomes a difficult point

of further comparison to us as the Chinese giant comes too strongly into the picture for the analogy to be continuously useful for the Brazilian case.

2.10 Conclusions

In the comparisons, we see patterns emerge with all three countries entering the 80s with their own industries created with similar characteristics of strong government protection. But whereas Brazil continued the protection strategy further enhancing it into the mid-80s and into the early 90s, Taiwan and Korea were already focused in becoming internationally competitive and aggressively pursuing foreign technology, either with capital from large national conglomerates or, in Taiwan's case, with increased direct government efforts. Brazil, in an inflection point of change in the 1990s, opted to try to create an electronics industry funded by the margins of its domestic consumer market, and from a portion of those margins mandate the funding of the creation and integration of specialized institutes and university research. The results seem to suggest too many goals for too few funds.

Evans and Tigre (1989) at the end of the 80s, hence before the IL, described the contrast between Korean and Brazilian electronics industries as the Korean specializing and seeking international competitiveness at the cost of losing (in that case) the opportunity to manufacture computer peripherals while Brazil had a much greater array of products being made in a more expensive way and aimed at a less competitive and smaller domestic market. This very same description would be applicable today with very few adaptations (and mostly in scale and not in form) to describe the difference in the electronic industry and innovation between the two countries in the 90s, the 00s, and the current decade.

The IL has not created a competitive electronics industry in Brazil. Sergio and Porto (2012) have drawn very negative conclusions regarding the failures of the IL noting that in over twenty years of continuous effort it has been unable to significantly improve the competitiveness of the sector it proposes to develop. It is hard to disagree with this assessment. We could add that foreign examples show that different, more flexible and adaptable policies have shown prodigious results over substantially shorter periods of time.

As we saw with the Korean example even a successful strategy can eventually exhaust itself and require change. As Chang (2003) reminds us the very strengths of the chaebol system in cooperation in research and diversification for cross-subsidy of nascent industry later became disadvantages, for while they allowed the development of success, they were also sustaining failing efforts. Brazil's efforts with smaller industrial groups in electronics has not faced the challenge of overgrown inefficiency, but neither has it surpassed the stage of nascent inefficacy as it remains essentially a domestic industry protected by taxation efforts. There is research that indicates that the R&D behavior of larger organizations is more influenced by government incentive policies than smaller corporations (Buisseret et al., 1995).

Nevertheless, the Brazilian policy has elements that are demonstrated as appropriate in other cases when applied in a larger scale. For example, Brazil seeks with its policy to create (and force) a greater interplay between companies, universities and research institutes. As we will see in chapter 3 and 4 these actions have been successful for certain players. The Taiwanese example has strong indicators of the capabilities of this policy, although it was funded primarily through government funds with its pathbreaking industrial/education park.

While as an industrial policy it might not have been successful in creating an independently viable industry, the question remains if the positive externalities of the mandated R&D are creating value in and of themselves. This will be our focus in the next Chapter of this dissertation, where we will argue that such question is not easily answerable. There is also the unknown of if (and if so, how) the legislation is creating domestically more expensive electronics that might be negatively affecting the rest of the economy, when compared to the job creation it is responsible for.

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5 - Conclusions

The current state of the innovation aspect of the Informatics Law is composed of too many unknowns for us to reach a definitive conclusion. Although it is important to highlight the difficulties in gathering relevant data for this sort of program, the Brazilian IL program is almost the ideal case for such data gathering. It is a long-lived program, that required annual reports of high relevance for the companies, and that are completed with a substantial level of detail. However, the very deficiencies in the data allow us to extrapolate some very relevant points and tentative conclusions about the legislation.

The first tentative conclusion is that the auditing and monitoring elements of the MCTIC don't allow for any objective perception of the underlying realities that the legislation is generating. The inconsistencies in numbers such as the ones we demonstrated on table 3.1 are worrisome by themselves, for they create a general uncertainty in the numbers presented; but the confirmation that the published data is the submitted data as opposed to the audited one is truly perplexing (ANNEX 1). Specially when considering the substantial rejections that the press and our interviewees experienced in their reports when they were analyzed by the MCTIC casts an additional shadow over the published numbers. Although the publication of this data is relatively new to have impacted academic publications, we have seen more political publication basing themselves heavily on those numbers (ABINEE 2018).

The frequent changes in the published analytical metrics suggests the absence of a sustained monitoring philosophy. The frequent abandonment of time series of data in the first decade and a half of the program deprive us of valuable data. This is especially relevant when seeking information on a sector that underwent such transformative changes in its global supply chain over a similar period of time. It begs the question of what were the effects that were produced over this period.

The delay in analysis of submitted reports reinforces the perception that evaluation of results was not a priority, and in many ways confirms the TCU analysis of the MCTIC efforts (TCU 2014). It is also indicative of the gathering of

data without a clear monitoring objective, hence the frequent scrapping of previous reporting styles and frequent discontinuations of time-series. Regardless of this negative view there has been undeniably progress in this front. Whereas before we had quinquennial reports, they are now yearly reports; and whereas once they were each individually different, they are now standardized. It is progress, but towards a very minimum threshold of quality. The delay in publication, however, puts us in the position of working with a time lag of three years even for the current deficient publication standards.

The legislation itself, in part, creates this difficulty. The goals of the IL are vast, seeking at the same time to foster an industrial sector, technically qualify human resources, and foster innovation (PRATES et al. 2006). The plurality of goals naturally creates difficulty in monitoring all those aspects, but from the current indicators being raised we can only reach the understanding that none of the objectives are being adequately monitored.

Several scholars have noted the general focus on the low technological level of assembly in the Brazilian electronics industry (HAUSSER et al., 2007, GUTIERREZ 2011). However, even within those parameters there can be room for increased industrial aggregate value; despite this not being the focus of our research, we have perceived that the technical requirement of the PPB has not evolved in over two decades, suggesting that at least the component of increased technological sophistication of the industry is apparently wholly unsuccessful. The limitations that the objections of the WTO about what they considered "nested" PPBs make the further use of the PPB mechanism for development of a domestic supply chain unlikely in the future, regardless of our views on its success or failure.

From an innovation perspective we see a close partnership between the IL and the *Lei do Bem*, especially the use of the products that have been classified as *Portaria 950* as an element of domestic innovation. Although the *Lei do Bem* is not a focus of our research, Zucoloto (2010) indicates on his specific research on the substantial increases of items classified under this legislation and benefit by its program. However, even when monitoring the results of other legislations, the controls by the MCTIC provide sparse utility, for example with the decision of

not opening the sales of products with *Portaria 950*, but only the total sales of companies that have **at least** one item with such benefits (ANNEX 2).

Such limitations create the impression of data being available, but once it is studied in depth and attempted use is made of it the limitations show themselves too great for utilizing the data for more definitive conclusions. The very delay in publication of this data has already made researchers reliant on different sources in hopes of studying the matter. As we can see in the research by Albuquerque and Bonacelli (2009), they produce an interesting study on the use of R&D funds by the IL on non-profit institutes but are unable to use any MCTIC data that was then unavailable - and now has the reliability problems we have stressed.

This perception of a lack of direction and care with the data was felt by the interviewed companies and institutes, who resented what they considered a retroactive changing of the rules on their obligations. This perhaps highlights the difficulty of having the same reporting tool for auditing an obligation and for performance measurement. While it does provide an incentive for all participants to answer, and consequences if answered untruthfully, it can also create an adversarial relation between auditor and subject.

The institutes remain a point of contention and frailty in terms of innovation. While the amount of their contribution in the IL has increased, our interviews found mixed reactions as to their effectiveness, specially for the geographical dispersal of the obligation. And the larger institutes were the most uncertain about their future viability with a potential change of legislation due to the WTO's recent positioning. While some of our interviewees also manifested satisfaction with the quality obtained, if the institutes became successful suppliers of R&D services it raises the question if the obligation of their hiring needs to be maintained. This is a crucial segment for performance measurement in the current structure of the legislation both for verification of additionality and its quality; alas the data in its current condition allows for no conclusion.

The very different profiles obtained between companies that make their own product and a contract manufacturer (CM) suggests that it will be very difficult to create a single rule would satisfy both profiles. Currently the CM profile

is the majority of the revenue in the IL, and therefore of the R&D obligation; the data by the MCTIC doesn't allow us to test each profile against the other, but our own (limited) interviews suggest that the CM profile obtains far lower results for their R&D than companies that develop their own products. A further study focusing on a representative sample of CMs that manufacture cellphones and personal computers would be very important to evolve in this line of reasoning.

More importantly, if substantial amounts of R&D expenditure are rejected in their final review, we can only be very suspicious of the validity and value added of such expenditure. At some point the post audit numbers will be released to the public, but the initial rate of rejection indicates a very dysfunctional relation between auditor and subject. This combined with strange data points such as a very large percentage of research being conducted by persons with only a high school education makes us very wary of the overall quality of the reported data and of the alleged R&D being executed.

The new standards of reporting suggest that there will be a greater agility in future responses by the MCTIC, but it is crucial that more sophisticated indicators be created and consistently applied. The use of standard indicators such as patents and publications were a step forward once introduced, but their distance from the actual objectives and practices of the companies, and the limitations of the Brazilian patent office make them of very limited utility. Older indicators of innovation from the perspective of the company, domestic market, or internationally was far more informative and should be revived.

Remembering that a hallmark of a successful R&D incentive plan is to create additionality, as Clarysse et al. (2009) indicates, we should seek a plan that increases the overall amount of R&D expenditures while not negatively affecting the effectiveness of the resources spent than in the absence of the program. Once we are not tracking results, but only limiting tracking the total amount spent, we are very far from determining if the entire program is generating overall additionality or not.

All this uncertainty and lack of data takes place amidst a continuously fluid situation. If the IL is to proceed under a new format to be determined, it is important to know how we seek to measure the results of our efforts. To able to

track this over time is a crucial element for self-correction and evaluation, and as we saw in international examples the capacity to change philosophical approach is a relevant element for sustained success. Due to the lack of information, we can only assume that all the minor changes being made throughout the tenure of the IL were made in the absence of substantiation with data. Therefore, changes in the composition of the IL R&D mandate that changed regional proportions, or proportions between public and private institutes were all made *ad hoc* and without a scientific approach. It is unfortunate, but the debate as to a potential new configuration of the IL, or its termination, will occur in a similar context of lack of information, especially in what pertains to the productivity of the R&D mandated expenditures element of the legislation.

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ANNEX 1

Communication from the MCTIC answering questions from the authors (translated by the authors)

09/25/2018 SEI/MCTIC – 3320882 – Internal Dispatch

Ministry of Science, Technology, Innovation and Communication

Secretary of Digital Policies of the MCTIC Digital

General-Coordination of Incentive of Digital Innovation

Coordination of Fomenting Innovation

Division of Research, Development and Innovation

Internal Dispatch

Process number: 01217.004524/2018-34

Interested Party: Henrique Nogueira Teixeira

Subject: Clarifications of information about statistics regarding the Informatics Law

Dear Sir/Mam

The Questioner asks by manifestation through the e-OUV nº 3303388 information about statistics regarding the Informatics Law. His questions, as well as their answers, are listed as follows:

1) The total number of companies in the 2014 report is of 510 companies in the annual report, however the time series statistics has a breakdown of company by size which if totaled will add to only 485 companies. What is the reason of the difference? Are there companies that provide an annual

report but don't fit any economic size? These discrepancies occur in the other years as well.

   a. The total of companies is the total number of companies habilitated for the legislation and therefore required to submit the annual report showing their expenditures in R&D. However, not all companies fulfill this obligation, not delivering their reports in the appropriate deadline, hence the difference in numbers.

2) The number attributed to expenditures of R&D per year is the total of approved projects presented or still includes items rejected or under analysis by the MCTIC?

   a. All the values of R&D applications divulged and in the statistical reports are accounted before the analysis of the presented projects. As of the present date the MCTIC doesn't present post-analysis results.

3) What were the expenditures in R&D projects due to the Informatics Law that were rejected per year?

   a. As of this moment, the MTCIC doesn't publish results post-analysis.

4) What is the percentage of the resources allocated in R&D obligation in each year as an obligation of the informatics law is completely analyzed and approved for each year?

   a. At the moment, the backlog for analysis of the years 2006 thru 2016 was completely analyzed. However, not the totality of the applications for R&D were approved. As mentioned previously the MCTIC doesn't divulges results of its analysis.

5) What is the percentage of resources allocated to R&D as an obligation of the Informatics Law that was rejected has the company objecting to the

original decision? Are there multiple levels to an appeals process? Is it possible to have the numbers and values currently in each level of appeal?

   a. After the expenditures in R&D are presented by the companies in their annual report, there is an analysis of these projects which results in an approval or rejection of the expenditures. The company can then appeal the result of this analysis and, in a last recourse, present an Appeal to the Minister asking for a revision of their appeal. As of the moment, the MTCIC doesn't publish the number of these appeals.

6) What values that were rejected were compensated in subsequent years? Are such values considered part of each annual report? In case they are separated, is there a way to list per year what was rejected and what was compensated?
   a. As of the moment, the MCTIC doesn't divulge number post-analysis.

7) What are the values of obligation in rejected R&D projects of previous years that were not compensated? If positive, what are those values?
   a. As of the moment, the MCTIC doesn't divulge number post-analysis.

8) Is there a detailed expansion of the R&D expenditures that were rejected and involved any research institute? If positive which institutes were affected?
   a. As of the moment, the MCTIC doesn't divulge number post-analysis.

9) The companies have the possibility of discounting from their R&D obligation purchases that were made from other PPB incentivized companies. Since such discounts are itemized in the company's annual reports, that is the total of said discount? Such number would give us an estimation of changes in the supply chain towards domestic producers.

Trying to clarify the question, what is the total of purchases of goods from PPB origin that companies placed on their reports seeking discount from their own future R&D obligation?

a. Among the information provided by companies is the value spent on the acquisition of other incentivized products. These values are discounted from the obligation of the company. This data is not divulged separately in the statistics reports, which presents only the final base calculation of the incentivized products.

Finally, for solicitations of this nature the Ouvidoria is the best path.

ANNEX 2

Additional Communication from the MCTIC answering questions from the authors (translated by the authors)

Internal Dispatch

Process nº: 01217.004975/2018-71

Interested: Anonymous

Subject: Solicitation of information about statistical dada related to the Informatics Law.

Dear Sir/Mam

The questioner asks through manifestation through the e-OUV portal nº 3453168 information regarding statistical data about the informatics law.

Following are the answers to the questions:

1) **The 2015 report counts the general number of publications and patents (item 6.4 pg. 17) and then a subdivision of this data in regards to originating from projects with partners (item 9.3 pg 23) and internal projects of the company (item 10.3 pg. 36). However, the sum of theses last two items does not equal the total presented in the first number. From where does the discrepancies arise?**

   The first item (6.4) corresponds to all the patents that the company pursues. The other two items (9.3 and 10.3) correspond to patents that were connected to projects declared by the company.

2) **The reports make mention of patents, but considering the delay in the actual granting of patents in Brazil are we presume we are actually considering patent requests. Does this proceed? Or the MCTIC waits for the patent to be granted in order to count it? If that is the case is there a control of the year it was requested?**

   This information corresponds to the number of requested patents. There is no subsequent verification if they were in fact granted.

3) **If true the above that are accepted only patent requests, is there any subsequent monitoring to verify if the patent was actually granted?**

   As answered in item 2, there is no subsequent verification if they were in fact obtained.

4) **Is there a distinction in the report about patents and smaller registries such as utility models?**

   There is no such distinction in the report.

5) **In case the number in the reports being only related to patents, do you have the data of requests for utility models?**

   As answered in item 4, there is no such distinction in the report.

6) **In case the report covers both patents as utility models can you open this data for the past five years?**

   As answered in item 4, there is no such distinction in the report.

7) **In graphic 3.2 of the 2015 report the title suggests that they are exports of all the incentivizes goods, but the total number is only of companies without any good declared as national technology. Is this a mistake or are there no export of companies with any good classified as of national technology?**

   In this item we account only for the exports of companies without any good classified as national technology. But this is not an indication that there isn't a similar data from companies with at least one good deemed of national technology, only they were not included in the graph.

8) **In case there has been exports with companies with at least one product of domestic technology, can this data be opened to us?**

   At the moment, this information is not being divulged.

9) **In item 5, in Areas of Activity there is a more advanced taxonomy of company activity. Is it possible to have not only the number of companies but the sales per segment of activity?**

   There is the possibility of organizing sales by area of activity, but as of the moment this data is not being made public.

10) What criteria are used to consider "publication" in this report? Are they academic journal publications? Are impact factors considered? Are conference papers accepted?

As regards of publications the benefited company inform if the project has generated or not any publication, not having a distinction as of now what kind of vehicle they were published at.

11) Is it possible to obtain a listing of publications and patents that were counted in the final report? After all they are both public documents by definition.

It is not possible since the information is not available. The company only informs if a particular project generated or not a patent or publication, with no further detailed provided in these items even in the case of an affirmative response.

Brasilia, 27 of September 2018