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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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3 - Analyzing a case of public policy driven innovation and industry incentive: the case of the Brazilian Electronics Industry

Abstract: This paper studies information recently released by the Brazilian Ministry of Science, Technology, Innovation and Communication on the results presented by firms benefited by the broad array of fiscal incentives informally known as the "Informatics Law". This new information has profound deficiencies in analyzing the program results due to strong deficiencies in data. In the context of the recent WTO initial finding against the legality of such incentives, Brazil finds itself on the verge of facing the necessity of changing the current incentive structure of a substantial sector of its economy with a limited amount of information. This paper will review the information available and point some substantial gaps in the data and their impact on policy.

Keywords: Public Policy, Informatics Law

3.1 Introduction

Brazil has been marked in its history by a variety of government programs aimed at developing selected industries. Although these programs have varied over time and industries affected, there is a relatively long-term incentives program aimed at developing the Brazilian electronic industry, in what became informally known as the Informatics Law. The detailed historical trajectory of the legislation has been extensively covered by other authors such as (GUTIERREZ, 2011) and (SOUSA, 2011). What can be understood as the totality of the Informatics Law is actually a collection of legislation and specific ministerial and presidential decrees whose minutia transcend the scope of this article[3].

In order to offer a very brief narrative, we start with the law 8.248 of 23 October 1991 where Brazil effectively abandons a previous strategy of a closed market that sought to spur national firms being followed since 1984. At the time, the basic mechanics of the current laws were created, with an expectation of being phased out over a period of several years as the domestic electronic industry was

[3] A listing of the relevant legislation can be found at the WTO decision (WTO PANEL 2017, p. 28-29).

expected to become more competitive and less dependent on the program. There have been some reforms on the legislation in 2001 with the law 10.176, where one particular tax benefit in the form of the reduction of the corporate income tax was removed (and later reframed in a different legislation named *Lei do Bem*[4]) but the major elements of the legislation are constant over the period (PROCHNIK; SILVEIRA; RIBEIRO, 2015). The most significant basic effect of the legislation is the drastic reduction (and in many cases the elimination) of an added value tax on industrialized goods (IPI – *Imposto sobre Produtos Industrializados*); there are other effects on other taxes such as the basic import tax, but those effects are arguably economically far smaller than the IPI reduction. Since in some cases this reduction can go from an added value tax rate as high as 15% to zero, it effectively makes it mandatory to join the benefit program for competitiveness in the domestic market of Brazil.

The effective objective of the legislation is to create an incentive program that would allow for the industry in Brazil to have a stronger grasp of innovative products and processes related to the Information Technology (IT) sector (MCTIC). Hence a two-pronged effort to join industrial activity with the development of R&D activity and therefore strive to produce an economically viable industry in the IT sector while developing the commensurable human resources to run and innovate in said sector.

Several of the analyses performed by other scholars, and the new data analyzed in this study, suggests the Informatics Law has three loci of interest in fomenting: (i) development of industry, (ii) growth of domestic R&D related to such industry, and (iii) job creation (RAMALHO; FERNANDES, 2009) (GARCIA; ROSELINO, 2004). The bureaucratic mechanism that is attached to the benefits of the legislation is also indicative of these priorities. The question, and the difficulty in analysis due to the paucity of data, is if the program as currently constructed is an efficient way of fostering innovation and if the results of the expenditures in R&D generated by the program are commensurable to the amount spent.

[4] For further information on the details of this legislation see (ZUCOLOTO, 2010).

It is never a simple task to gauge results of R&D, Brown and Svenson (1988) propose a schematic for measuring inputs, processing systems, outputs, receiving systems and outcomes that is reasonably apt for corporate applications. Nevertheless, the complexities of such tasks have been studied by others such as Scheinblatt (1982) who saw the greater importance, and challenge, to measuring the productivity of R&D was finding outputs that were comparable over time. Brown and Gobelli (1992) propose a flexible framework for corporations to find the characteristics they wish to foster and measuring criteria against it. Other research such as Pappas and Remer (1985), all recognize the difficulty of the task of measuring the productivity of R&D in any objective way. This should demonstrate that the task is far from straightforward even when applied to an organization, once the challenge is expanded for a government incentive program it is natural to reach tentative answers, but hopefully enlightening ones.

The timely and pressing nature of the question is driven not only by the appropriateness of always measuring the effectiveness of our public programs, but also by the World Trade Organizations (WTO) recent decision against the IL. As we have seen in previous chapters, the WTO has found against the IL, precipitating the probable need to changes in the IL to conform to WTO parameters (WTO Appellate Report 2018).

In this context, the main objective of this paper is to analyze the data recently released by the Brazilian Ministry of Science, Technology, Innovations and Communications (MCTIC – Ministério da Ciência, Tecnologia, Inovações e Comunicação) in order to better understand the current situation and generate fuller understanding necessary for future changes that the legislation may need to undergo. A review of the current results would allow for a fuller and more effective adaptation (or closure) of the incentive program aligned with the stated objectives. We will also review other periodic reviews of data that occurred in the past, but recently publicized information must be placed in context and analyzed.

In general terms, as we will see below, the legislation has had a moderate success in creating an electronics assembly industry in Brazil, where imported components are assembled into finished products through basic electronic manufacturing tasks – such as the soldering of SMT components into circuit

boards. Different programs were created in attempts to develop a local component industry and, while we will not go into great depths into these other programs in this article, they were mostly unsuccessful – Brazil remains an importer of the substantial majority (if not near totality) of the electronic components used in its electronic assembly industry. Nevertheless, the issue of fostering a national component supply chain is relevant for the analysis of the Informatics Law for, as we have seen, it is one of the major elements criticized by international agencies such as the World Trade Organization (WTO) and the driver of the ongoing discussions on the need to adapt the law in face of such criticisms.

3.2 Methodology

This work is built on the foundations of the public available information made available by the MCTIC. Most of the publicly available information has been recently published by the MCTIC and is available in their website, we will describe and refer to this data extensively. After a review of all the available public data by the MCTIC we sought some clarifications and additional information with the ministry, the answers provided by the ministry are referenced in this paper and publicly available for consultation. We also reviewed previous academic and public studies on past periods of the Informatics Law (IL), and evaluated their conclusions and data.

Our methodology seeks to create and evaluated compilation of the recently available data, especially since it is already being used by class associations such as ABINEE and the regular press despite some serious limitations that our research has uncovered about it. As a result, an evaluated aggregate of the data is timely for the discussion to come.

Due to the recently larger recent amount of data made public by the MCTIC, we present a brief overview of the reviewed data (mostly made available publicly online on 2018), along with the previous analysis of the IL from older periods also conveniently gathered by the MCTIC in proximity to the newly published data.

3.3 A Review of the Ministry's Data

The practical mechanism of the incentive legislation requires the companies and benefited institutions to file detailed reports of the activities that were funded by IL mandated funds. There has been a historical scarcity of information regarding the results of the informatics law, that were diminished as greater amounts of data were made publicly available online. The difficulty of extracting such information and the quality of the information provided by the companies and institutes has been a subject of government debate including by Brazil's government auditing body *Tribunal de Contas da União* (TCU), who perceived a lack of auditing criteria and agility by the MCTIC in their regulatory role over the expenditure IL mandated R&D funds (TCU 2014).

As a probable result of this a greater amount of information has been made recently available or updated at the MCTIC website under a prominent section titled Results of the Informatics Law. What follows is a brief overview of the available data on the website:

I) <u>Statistical Reports of the Informatics Law</u>

This section is comprised of annual reports whose format and composition of data change year-to-year until a stability if found in the report of 2011 where a basic format is preserved on subsequent years. Although many statistics were preserved from previous reports, it is a viable speculation that there were still experiments on how to best present the data. It is especially noteworthy that 2011 is the year that the presenting format is stabilized since it followed 2010 which is the year with the sparsest report.

It is regrettable that certain efforts that might have yielded interesting data if placed in a time-series are sometimes present on the report of only a single year, as an example the report of 2008 includes a classification of the expenditure as innovative to the company, to the country, or overall on the self-assessment of the entity presenting the report (MCTIC Relatório 2008). No subsequent year utilizes this taxonomy. It should be noted that all reports from 2006 through 2014 were uploaded into the web (or updated) on October 9th 2017; with the reports for 2015 made

available on July 4th 2018 and the latest entry being the 2016 report on November 7th 2018. Clearly showing a recent effort on trying to bring the data up to date and to the public.

II) Historical Series of Results of the Informatics Law

This section is a single file with the elements that were present through the several changes in the reports over the years in a time series. As it was also uploaded on October 9th 2017 and therefore lacks the public data already made available on annual reports for 2015 and 2016. As a result, when presenting time series data, we recreate the time series incorporating the elements of the more newly published reports in the time-series already produced by the MCTIC, always with the appropriate caveats.

III) Statistical Reports Since 2006

This subsection presents the same reports as section I, but brought to the public at a different time. The bulk of the reports, 2006-2014 were uploaded on August 18th 2017, nearly two months before the same report on section I. The year of 2015 has not been presented on this section at all, while the year 2016 has been dated the same date (November 7th 2018) as the uploaded in section I.

IV) Evaluation of the period of 1991 and 1998

Here are reproduced segments of an evaluating report of the conducted of the period when a different legislation than the IL was in effect of the information technology sector. Although out of order, most of the report can be read through the provided links.

V) Evaluation of the period of 1998 and 2008

This is a large report created by Unicamp in conjunction with the MCTIC (called MCT then), concluded on December of 2010. It brings considerable data on national accounts and relies relatively little on the MCT data produced by the annual reports filed by companies and institutes. It is also a frequent source in academic research as it was, until recently, the most recent data publicly available on several matters regarding the R&D and other elements of the Informatics Law.

VI) Evaluation of December 2003

A small two sheet introduction to an event on July 2004 (likely the one where several publications of the item VIII were presented due to similar formatting) where results of the IL were discussed. There is no data other than a small introduction.

VII) Evaluation of March 2006

Three booklets containing a review of pertinent ministerial decrees and legislation regarding the IL, especially relevant is what is named *Livreto 2* (translates roughly into “booklet 2”) which also discourses on the objectives of the underlying legislation and resulting industrial policy.

VIII) Publications

These are publications sixty-nine small reports of recent activities produced by various entities (companies, universities and institutes) that are benefited from the Informatics Law. The general data is from the early 2000s (mostly 2001-2004). Each report follows a different format and presents their results in a different way making them not comparable. The most notable element is that several entities list the publications created over the time period regarding IL resources.

3.4 Mechanics of the Legislation

The mechanics of the Informatics Law can be briefly summarized as a particular product must adhere to the approved production process created by the MCTIC. The production process is a tailored document for each specific product that intends to benefit from the fiscal treatment of the legislation, and the description of said process is considerably detailed. Any firm producing that particular product, in order to use the special reduced fiscal treatment, has to follow that particularly specified production process. The resulting description of industrial process is named a Basic Production Process (PPB - *Processo Produtivo Básico*) and the company must document their adherence to the particular process of their products in order to remain compliant with the legislation.

The level of detail in the description of these production processes is considerable; it lists what particular industrial tasks must be performed within the national territory of Brazil and what particular components can be imported. Naturally it is in the frequent revisions of the PPBs that government and local industry negotiate; the government usually tries to increase the number of industrial tasks and components to be performed or manufactured domestically, while the natural desire of industry is to minimize that amount, especially in cases where the local availability of a particular service or item will be less economical and have the effect of reducing the true benefit of the tax reduction engendered by the legislation. It is by the increase in the national content of industrial tasks and components that the program hopes to, over time, increase the scale and value of the Brazilian electronics industry. This results in effect in a “nested” PPB (as the WTO names it) in that the adherence to one particular PPB requires the purchasing of products that are themselves subject to PPB benefit.

It is by the continuing evolution of the PPB that the government hopes to foster the development of specific component industries. The inclusion of a particular component into several PPBs would naturally create a captive market for such components that could, theoretically, overcome any competitive difficulties that the small-scale emerging component industry would face from international competition. As we will see below, it is dispiriting that the

government's data acquisition and analysis efforts have not focused on the success of this particular aspect of the program.

The legislation also requires an additional compensation for the fiscal benefit, in addition to the adherence of the PPB, in the form of R&D expenditures to be performed in Brazil. The legislation requires that a percentage of the revenue, obtained through the sale of the incentivized products be spent on R&D performed in Brazil.[5] The legislation is quite specific in creating a geographical and institutional division of this percentage. The legislation mandates that a segment of the R&D mandated funds be sent to a government fund, a segment be spent on approved public institutes in the north and northeast of Brazil (hoping to foster technological development there), a segment spent on either public or private approved institutes in the north and northeast of Brazil, a segment spent on approved institutes anywhere in Brazil, a the balance in internal firm expenses. As the listing shows there is considerable focus on achieving geographical and institutional dispersion. The actual percentages and distributions of these obligations have varied over time, and as we will see from some deficiencies in the data, it is hard to imagine by what objective standard each of these changes were motivated.

It should be noted that the FNDCT fund is a government fund dedicated to financing R&D, so it is not directly any form of R&D by the firm, but it is aggregated in the law as if it becomes part of the R&D obligation of the firm as in a tax to a general R&D fund. Nevertheless, the geographical dispersion aspect becomes clear with the addition of specific obligation towards partnerships with research centers located in historically less advanced technological areas of Brazil in the North and Northeast. The success of this policy in developing greater technological expertise within these regions is difficult to ascertain with the known data. Attempts to find such development in these regions with a deeper analysis of a smaller dataset have found some level of progress, but with limitations as to the specific role of the legal mandate on the matter (FIGUEIREDO, 2011).

[5] The general case is 4% of the revenue, but for some more specific products the percentage can be lowered to 3%. For the special cases the same subdivision of geographic and institutional distribution occurs pro rata.

The benefited company is obligated to make a report by March of the following year listing in great detail the expenditures made and how such expenditures were allocated within each of its R&D projects. The concept behind this was for the MCTIC to review these reports and, in case any particular expenditure was found to be irregular, require the company to perform the payment of any deficit towards the FNDCT Fund. In practice, however, the process of reviewing the R&D reports (which are very extensive) coupled with the administrative appeal process permitted to the firms has created a substantial backlog of reports whose analysis has not been performed, or concluded (Relatório AvalRDA). A worrisome item revealed by this research in communication with the MCTI is that all the public R&D data available is only the initial data delivered by the companies to the MCTI, and not the result of what the analysis of the MCTI has considered a valid research expenditure (ANNEX I). There have been reports in the general press that a very substantial percentage of the backlog for analysis was considered invalid as a research expenditure by the MCTI (MP 2018). Reports also indicated that as much as 90% (ninety percent) of the submitted amounts as R&D expenditures were rejected as such by the MCTIC (INDUSTRIA, 2018). These reports were found consistent in our selected interviews with companies and institutes who also experienced very high levels of rejection of reports by the MCTIC (see Chapter 4)

While it is likely that the number of rejected projects will fall as companies re-file their reports, currently there is, no breakdown of year, reason for the expenditure to be found invalid, or geographic/industrial sector detail of the rejected numbers available for research. We were considerably surprised that a data that has been initially (and currently) 90% rejected has been published without such caveat by the MCTIC and has been seen in other published research without this important caveat. It is clear to us that the provisory nature of the currently published numbers is not a matter of general knowledge.

The failure to perform the necessary mandated R&D expense can have serious consequences, the firm can either pay the necessary balance to the government FNDCT fund or lose retroactively all the tax benefits obtained in the preceding year. Naturally the former is much smaller than the later. This recent large rejection of expenditures by the MCTIC has created a potential serious

liability for the firms, there has been political considerations to create an exception that this particular rejection of reports could be compensated with R&D expenditures (as opposed to payments to the FNDCT government fund) over a period of 48 months (LEI, 2018).

3.5 Previous Studies and their impact

Although the issue has been systematically investigated by academics, there is still no consensus regarding the results being obtained by the Informatics Law. There are a few studies trying to ascertain such results, and they are mostly reliant on the data made available from the MCTIC (see references). Since the data is sparse, some previous researchers have performed their own limited surveys among larger benefited companies such as the analysis conducted by the Inter-American Development Bank (IDB). From their data and analysis they conclude that the competitiveness of the electronics sector in Brazil remains low and that the firms would be perennially dependent on the incentive (SERGIO; PORTO, 2012).

In a similar effort others have focused on international comparisons, trying to find comparable efforts in Latin American countries (OLAVARRIETA; VILLENA, 2014), or comparing to the successful Chinese model (ARAÚJO, 2013). Fundamentally, the analyses find in Brazil a growing level of industrial activity associated with the benefit program, but have difficulties in finding if the challenge of a larger and more economically sustainable industry is to increase the level of incentive and scale of the program or to reduce the current triple foci from employment, R&D, and industry development towards a single objective.

One of the most cohesive and methodologically sound attempts to assess the impacts of the Informatics Law is a study conducted by the University of Campinas (UNICAMP) in partnership with the Brazilian government released on December 2010 (Unicamp, 2010). This study combines an analysis of the previous published data from 1998 through 2008 with an empirical field research with companies that generates an analysis of the results of the Informatics Law and methods to improve on the obtained results (Unicamp, 2010)

Their methodology is interesting in that while they use the raw data from the ministry (which unfortunately was denied for this research), they also complement

their analysis with a survey directed at companies and relevant research institutes, interviews with 30 selected companies and institutes, and data from other Brazilian official entities such as the IBGE (the Brazilian Institute of Geography and Statistics). Nevertheless, they do not address the limitations of the non-audit of the data by the ministry, and hence we don't know how (and if) they made any adaptations due to this limitation.

It is possible that the 2010 UNICAMP study has altered the methodology of public reporting by the ministry on the results of the informatics law. This speculative conclusion is based on the fact that the government report substantially changes after 2010, includes many of the new statistics in the format developed for this report (specially relating to publications and patents requests), and the report for the year of 2010 – the same year that the study was released in December- is substantially abridged.

In fact, disappointingly, a substantial amount of data is lost to the public in the new format that is used after 2011, including a breakdown of domestic products sold with incentives, domestic products with patents sold, sales of products with domestic vs foreign technology, and other quite interesting date. We can speculate as to the reason, the data provided before 2010, while interesting, is quite contradictory within the report itself. As a brief and clear example, if we total the sales of incentivized products sold, with data from the same page of products sold with domestic technology and external technology we obtain different results. Sometimes so small as to be easily attributed to a rounding error, other times considerably large and swinging from negative to positive variations suggesting also year-over-year discrepancies.

Table 3.1 demonstrates the differences found the in very same page of previous MCTIC reports:

Table 3. 1 Inconsistency in totals from the MCTIC reports

	2006	2007	2008	2009
Revenue from incentivized products	R$ 15.929.309.287	R$ 21.007.618.563	R$ 24.675.442.526	R$ 23.656.086.342
Sum of the detailled subgroup - Foreign technology and domestic technology	R$ 15.929.309.287	R$ 20.817.159.304	R$ 24.829.805.584	R$ 23.568.298.387
Diference	**R$ 0**	**R$ 190.459.259**	**-R$ 154.363.058**	**R$ 87.787.954**

Created by authors from the report data of the MCTIC

Since the UNICAMP study never addresses such differences in their conclusion, we don't know if they worked with corrected numbers not available to the public or if they somehow found a different source to correct the data on their analysis. Nevertheless, despite these potential limitations that strike at the confidence we can place on the data, the UNICAMP study marks a major change in quality in subsequent MCTIC reports. In it we see the emerge of new indicators such as numbers of publications and patents sought given more prominence and the general scope of the report stabilizes over the following years into a continuous format. While we will discuss in great detail the limitations of the data subsequent to this study, it would we would be remiss if we failed to mention that it marks a qualitative jump from previous reports and efforts.

Other government agencies in Brazil have highlighted the lack of data and accountability that has permeated the program. Namely the Federal Court of Accounts (TCU – *Tribunal de Contas da União*) published in 2014 a rather scathing review of the MCTIC performance in reviewing the obligations by companies created by the legislation. The findings of the TCU were, among others, that the computer system used by the MCTIC to receive and store data from the companies was woefully inefficient for data extraction, and that as a result the R&D reports were behind schedule for analysis and aggregate numbers for the program were mostly unavailable and had to be manually generated (TCU 2014).

3.6 The recent data released and its limitations

Recently the MCTIC has enhanced its efforts of analysis of past reports and publication of some aggregate reports of recent years. As can be seen on the MCTIC website, a small amount of aggregate data up until the year of 2015 has been made available, unfortunately this means that the more recent impact of the economic crisis of 2016 both on the Brazilian private sector and public expenditures will not be reflected in the data (MCTIC, 2017). It will be particularly informative to see how resilient the R&D expenditure will show itself being an

obligation but attached to a potentially declining revenue as industry sales contract on the recession started on 2016.

More frustratingly, and perhaps confirming the view expressed by the TCU in 2014, when the authors reached the MCTIC for additional breakdown of the published information they were told that such data was not available, and all the data they effectively had was already shared on the published annual report (such reports are approximately 40 pages long heavily reliant on graphs). The numbers that are available greatly suggest that the program has had limited effectiveness in some of its goals, but as we will see the limitation of the data set implies that it is currently impossible to track more than the broadest elements of the program.

A more disturbing perspective it the information provided by the MCTI that the published numbers are not the result of the overdue analysis recently finished, but that they are the numbers originally submitted by the firms before any audit by the MCTI found any R&D research invalid. Therefore, even the limited available numbers have potentially a very large bias towards an invalid R&D expenditure. No formal number is known but the press has reported that numbers as high as 7 billion *reais* have been deemed invalid by the initial MCTI assessment (INDUSTRIA, 2018, Chapter 4) that would mean that the vast majority of the R&D research mandated by the Informatics Law has been deemed invalid by the MCTI.

The situation, however, is not necessarily as bad as that initial impression would indicate. The system for data entry developed by the MCTI requires a very large amount of detailed data. Therefore, it is possible that clerical errors generated the invalidation of some R&D expenditure that can easily be proven valid with supplemental clerical data. As an example, the current reporting system requires that all invoices and man-hours spent on the R&D project be individually itemized. A clerical mistake on hour allocation or invoice information can, in theory, be corrected. The necessity for large scale reevaluation of past reports has led the MCTI to publish more detailed rules on the process of review of the annual submitted report and deadlines for answering the MCTI questioning related to the report (BRASIL DOU, 2017)

However, since we are already dealing with a near ten-year delay on data analysis, it is hard to consider the reporting and audit process as anything but unsuccessful. Additional difficulties are created by the lack of explanatory text in

the publication of the data, where apparent contradictions create an illusion of error where there are actually different definitions that were not clearly stated.

The data that we have available by the MCTI is an annual report where a particular set of data is presented in simple graphs. No data file is available (in the site or upon request), and generally the graphs are presented with little or no explanatory text. While some numbers are quite self-explanatory, as we will see some have more nuanced differences that could have been made explicit in the report. To itemize what is publicly available by the MCTI, we have:

Annual reports from 2011-2016 that contain:

1) Number of companies
2) Regional Distribution of Companies (state)
3) Total Gross revenue of companies – with four categories (incentivized goods, software, services, and others)
4) Expansion of the "incentivized goods" category above in three subcategories of: a) microcomputers and tablets, cell phones, and others.
5) Geographical (by region, not state) dispersion of total gross revenue.
6) Gross revenue of "incentivized goods" by state
7) Gross Revenue of firms with at least one national technology product within the incentivized goods category (but not using the subcategories of item 4 above)
8) Volume of export revenue with a classification of: a) products of companies with at least one national technology product, b) products of companies without any national technology product, c) software, d) services, e) others.
9) Exports of incentivized products by state (although it is actually only of products without national technology as the title leads the reader to error).
10) Export of incentivized products by region (in the same definition of product as above, not counting the national technology ones).
11) Import by companies apt to receive the benefits of the informatics law, subcategorized as Imports for the manufacture of incentivized

products, finished products for resale, software, services, and other imports.

12) Areas that companies act (noting that a company can act in more than one) – here we see an interesting taxonomy for companies not used elsewhere in the report that we will expand below.
13) Total employed persons by benefited companies, with the subcategories of: a) those with a college degree or higher, b) those who act in R&D, c) those who act in R&D with higher education
14) Total persons directly involved in projects generated by the Informatics Law in accredited institutions (usually universities or research centers).
15) Total persons indirectly involved in projects in accredited institutions.
16) Patents and Publications
17) Taxes paid in the sale of incentivized goods – segregated by state and tax.
18) Foregone tax revenue on IPI segregated by state.
19) R&D expenditure due to incentive – segregated into categories of internal projects, projects with accredited institutions, deposits to the FNDCT, and payments to priority programs. Subsequently a division of the total of the above by state.
20) Value Spent on internal company projects and institute partnerships projects per area of interest.

As an initial relevant data set, we have a limited historical evolution of the number of firms that are actively benefiting from the program and submitting reports. As Table II shows the number of firms that benefit from the informatics law and therefore submit the report is relatively small, and quite dispersed among relatively small sized firms whose respective R&D obligations will be equally small as they are proportional to sales. More worrisomely the data presented in one point of the time series suggest a certain number of companies participating in the program, but a later breakdown by company size leads to a different total than the original number.

Table 3. 2 Number of companies per year participating in the IL

	Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Source graph 1 MCTIC	Total Number of Companies	262	313	370	439	437	437	456	489	510
Source graph 2.3 MCTIC	Large Companies						37	39	44	47
	Medium-Large Companies						47	52	54	69
	Medium Companies						138	143	150	155
	Small Companies						156	165	175	176
	Micro Companies						43	39	44	38
	Total						421	438	467	485

Source MCTIC material

The report uses the same scale applied by the Brazilian national development bank (BNDES) which uses yearly net operating revenue for determining company size	
Large Companies	Greater than 300 million reais
Medium-Large Companies	Between 90 and 300 million reais
Medium Companies	Between 16 and 90 million reais
Small Companies	Between 2,4 and 16 million reais
Micro Companies	Smaller than 2,4 million reais

Naturally such discrepancies create a large feeling of insecurity towards the accuracy of the data, which as we shall see is considerably limited. Our consultations with the MCTI have cleared the issue indicating that the difference is that firms that were eligible for the program but did not submit any report to the MCTI were considered for the first graphic of number of firms, but not for the second on of firm size (ANNEX 1). The obvious conclusion then is that approximately four percent of firms that are eligible for the program that have not submitted their reports. We make that explicit below on Table 3.3. Since this data was published only on 2018, we cannot say how going forward MCTI will deal with these past unsubmitted reports. It is uncertain if they will resubmit previous years data if any of these companies deliver late reports, if they will be tabulated separately, or if they will be accepted at all. They were also unable to provide any scale of operations (if any) of the non-reporting companies. (ANNEX 1)

Table 3. 3 Inferred number of companies that didn't submit report to MCTIC

Year	2011	2012	2013	2014
Graph 1 MCTI	437	456	489	510
Graph 2.3 MCTI	421	438	467	485
Not Report Submitted	16	18	22	25
Difference %	3,66%	3,95%	4,50%	4,90%

Created by authors

The lack of a breakdown of company size before 2011 stops us from extrapolating any trend on the unsubmitted report statistic. But it is symptomatic of the limitations of published data when it is known that the amount of data received by the MCTI would allow for a much more interesting study. For example, the companies that didn't submit reports were active in which sector, had they submitted reports previously and stopped or simply never submitted one, and a variety of other basic information that would allow us to see if these were companies that never operated or that for some reason failed and stopped operations. A very basic survivability test is embedded in the data, but unable to be performed due to these limitations.

As an indication that the depth of the data available is also limiting, we can see the growth of the number of companies per category, but on the information made available of the evolution of the benefited revenue (Table 3.4) we can only ascertain the general growth of the benefited revenue, but not ascertain if any particular category of firm has had a disproportional increase. We will continue to see this poverty of detail for analysis thorough the data.

Table 3. 4 Growth in total revenue and revenue of benefited products

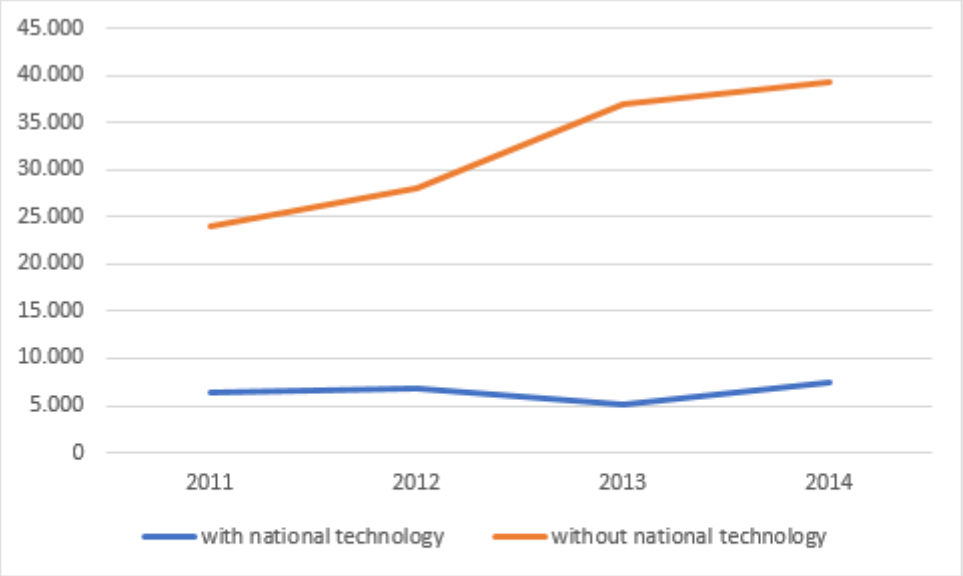
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total revenue	37.823	42.115	49.185	48.322	56.445	62.422	72.950	89.038	103.653
Revenue of benefited products	15.929	21.008	24.675	23.656	27.232	30.320	34.746	41.879	46.604

Created from MCTIC data by authors

A different objective being pursued by the MCTIC, and a general development strategy followed by several Brazilian laws has been the creation of an accreditation of a "nationally developed product". This accreditation is conferred

by the MCTIC after analysis of the product itself and the local R&D staff that has developed it, it is made public through a type of announcement called *Portaria* 950 which confers additional tax reduction[6]. Although the specifics of this legislation are not originally from the Informatics Law, since its use is an element of the report produced by the companies the total sales of companies with at least one product of the *Portaria* 950 is segregated in the MCTIC report due along with the Informatics Law's benefits.

Figure 3. 1 Sales by companies with at least one product of national technology (*Portaria* 950)



Year	2011	2012	2013	2014
with national technology	6.379	6.733	5.019	7.405
without national technology	23.941	28.013	36.860	39.200

in millions of reais

Source: MCTIC data

As the Figure 3.1 shows there is no growth in the sales of companies with one product deemed of national technology, and that doesn't inform us if the products sold by the companies were in fact the ones nationally developed – it only shows the total sale of companies that have at least one such product. The lack of such growth is particularly notable since the period in question was a period of heavy investment by the Brazilian oil company Petrobras which gave substantial

[6] Incidentally the benefits of the Portaria 950 were also considered a violation of WTO rules by the WTO panel (WTO 2017).

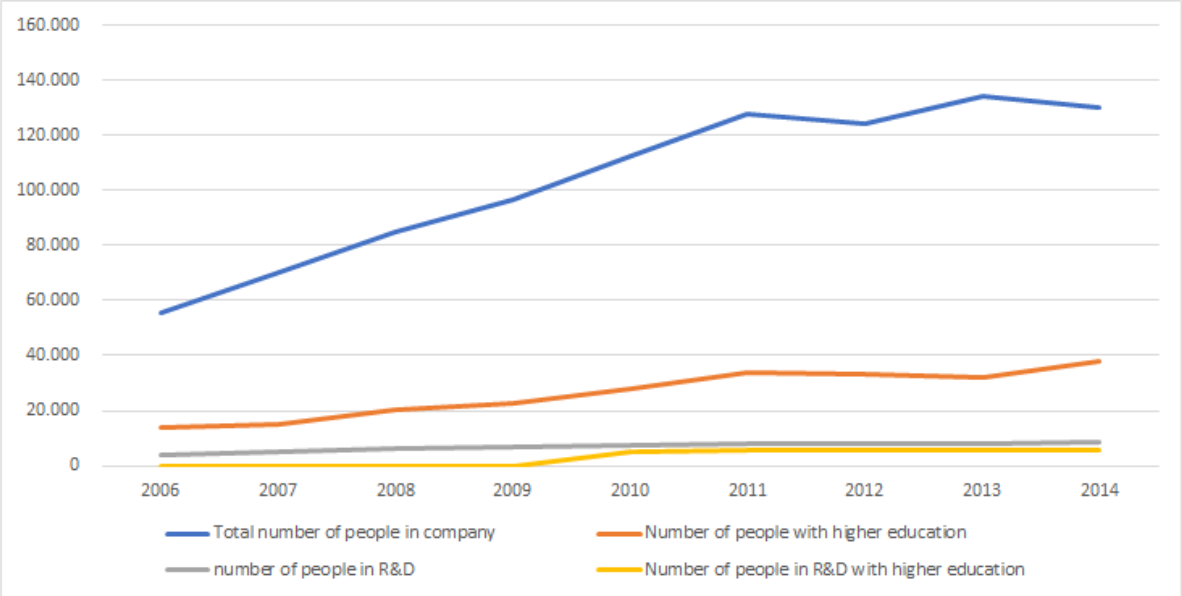
preferences for domestic content. Consultations with the MCTIC confirmed that they don't have a segregation of the revenue by sector, which could (perhaps) show us the behavior of the oil and gas sector in such purchases across the period (ANNEX 2). The only sector segregation available are for "computers and tablets", "cellular phones", and "others" – with "cellular phones" accounting for the largest increase in sales. Nevertheless, it remains clear that the growth that has occurred in the period has been substantially in the non-domestically developed category

This lack of detail is particularly vexing since the MCTI report specifically requires information on the nature of the incentivized products sold, and the reduction of IPI of the products that do have the benefits of the *Portaria* 950 could easily be drawn from there. It is predictable but uninformative that if we create a taxonomy where a single product being classified as nationally developed will place the entire revenue of the firm into a different category that this category will increase over time. However, this is not an informative data for us to study the growth of domestically developed products.

The politically more potent element of a development program is usually job creation, and the growth in revenue has been followed by a growth in the number of people hired by the benefited companies (Figure 3.2). Disturbingly the largest number of employees and growth has been in the category of those without higher education – in this taxonomy the American equivalent of bachelor degree. More disturbingly a substantial percentage of those engaged in R&D are also without higher education, which elicits the question as what is their role in R&D activities. While the reports filed by the companies must account the participation of each employee for each R&D project by the hour, the MCTIC could not even segregate the people or amount spent by sector of the economy upon request; again, reinforcing the criticism of the TCU in 2014 about the oversight of the program (ANNEX 1, TCU 2014). Nevertheless, the substantial number of high school educated (or less) workers indicates an industry largely focused on assembly. While their growth is compatible with the growth in revenue, the MCTIC could not provide, upon request, information on productivity gains or profitability, both indicators whose increase would show a growing competitiveness by the domestic industry. Previous studies have shown how low innovation sector of the Brazilian economy have tendencies towards innovations that are only an

innovation for the company and not for the market, and particularly focus on automation for the substitution of labor and not necessarily a product innovation not related to the production process (PROCHNIK 2004).

Figure 3. 2 Segmentation of Education of Total Employees and those involved in R&D



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total number of people in company	55.388	70.221	85.087	96.814	112.397	127.996	124.501	134.295	130.092
Number of people with higher education	13.802	15.055	20.142	22.843	27.984	33.662	33.007	31.986	37.906
number of people in R&D	4.108	5.261	6.043	6.746	7.244	8.068	7.994	8.122	8.436
Number of people in R&D with higher education	NA	NA	NA	NA	4.996	5.590	5.644	5.891	5.896

Source: Created by authors from MCTIC data

While it must be noted that the growth in R&D personnel has not matched the general growth of people in the company, it must be stressed that not all activities within the company are necessarily involved with items benefited by the Informatics Law and therefore generating a corresponding R&D obligation (see Figure 3.2). In fact, in the MCTI publication of data shows a large growth on non-benefited activity in the companies that operate within the Informatics law. As a result, the statistic of “people in the company” will potentially overstate the actual impact of jobs directly created by the Informatics Law and potentially this skewness has increased over time as the non-benefited activity has outpaced the growth of the benefited production. Therefore, while the information of personnel

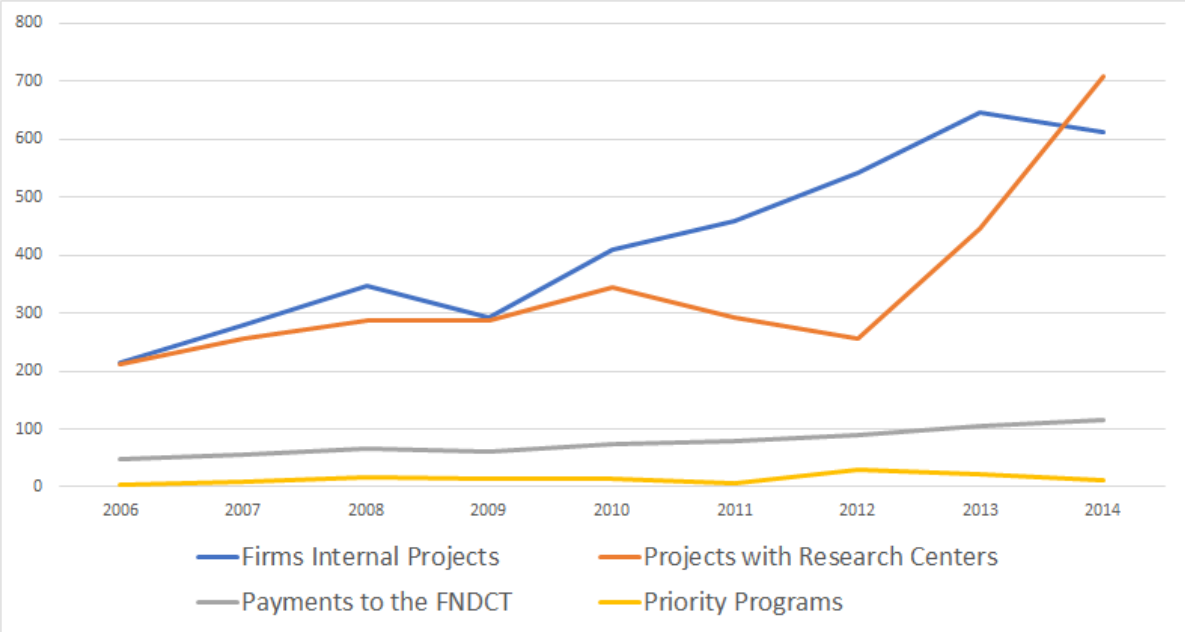
within the company is of limited clarity, the absence of estimates of supply chain impact on job creation or industrial innovation creates a gap in information that leads the skewedness in another direction.

Since the nature of the PPB is to create a series of industrial tasks which must be performed within Brazil, and not all those activities are subject to a PPB of their own, the true extent of the indirect employment created by the legislation is unavailable in the data and can probably only be grossly inferred through econometric methods. The nature of the benefit in value added taxation encourages industrial verticalization to a certain extent, but that data is also unavailable in the MCTIC information. Also, relevant, one must remember that according to the legislation, if a company purchases from another manufacturer that uses the PPB process it can discount that value from its R&D obligations – which is to avoid a particular item generating R&D several times as it travels across multiple PPB processes. The tracking of this particular number, the discounted R&D obligation, would be an interesting indication of the connectivity and density between PPB manufacturers, but unfortunately it is also unavailable according to the MCTIC (ANNEX 1). Not only that, but in the nature of the reporting the specific supplier and invoices have to be referenced, and therefore this would allow for a segmentation of sector and product types where the supply chain was becoming denser. This is particularly unfortunate since it could be a significantly good metric for the evaluation of the success of the increased growth of the Brazilian components industry. In effect, the number is already provided in the report by the firms, all that is needed is to tally the totals and create a classification system for analysis, and while the difficulties of the information systems already mentioned by the TCU audit can be a hindrance, it is difficult to imagine that such a number could not easily be manually produced for a group of less than 600 annual reports.

The final element of the program, the fostering of R&D projects within Brazil accounts for a substantial percentage of the data released by the MCTIC. As can be seen on Figure 3.3 there has been a natural growth that is expected to occur with the noted increase in revenue. It is strange, and largely unexplained, the reason for the sharp increase with projects with research centers in the years of 2013 and 2014. It is public knowledge that there is a

considerable backlog of analysis of companies R&D reports, and that it is expected that such reports will generate substantial obligations for companies whose R&D projects were not approved by the MCTIC (MCTIC 2 2017, ANNEX 1). This creates the additional problem in analyzing the data below in that it still partially subject to change in that substantial portions of it could be considered by the MCTIC as not legitimate R&D expenditures.

Figure 3. 3 Values Spent on R&D due to obligations by the IL



Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Firms Internal Projects	214	280	348	292	410	459	541	647	611
Projects with Research Centers	211	257	286	287	345	293	257	445	709
Payments to the FNDCT	48	56	65	62	73	80	90	105	115
Priority Programs	4	9	17	13	13	6	31	23	12

Source: created by authors from MCTIC data

More limiting, the MCTIC has been unable to provide a sector and type of project breakdown. Since the majority of the revenue is being obtained through the sales of cellular phones, computer and tablets, has the respective investment in R&D been applied similarly in those sectors as others? It is possible that firms that are the larger manufacturers of electronics do not have a domestic developmental background, in which cases the question arises if the productivity of their R&D is comparable to companies that have such a domestic developmental background.

3.7 Patents and Publications

The only indicator of R&D output produced by the MCTIC is the number of publications and patents obtained per year by the incentivized companies and institutes. This is a frequently used indicator to evaluate R&D as Lanjouw and Schankerman (2004) apply it in sophisticates metrics, while aware of its limitations as a measure of output of R&D and hence a proxy for productivity in R&D expenditure.

There are relatively small numbers of produced patents or publications as can be seen in the figure 4.2 which summarizes the data from the MCTIC sources. However, that numbers themselves might be less descriptive than their increase over time. It is entirely possible that the smaller companies that dominate the majority of companies (but not revenue) from the IL aren't focused on generating publications or patents. As Pereira (2011) indicates the Brazilian backlog and delay in granting patents exceeds nine years and can have a profound chilling effect on the demand for patent protection. Therefore, there is a substantial risk that this is an indicator that, while academic valid and of long use, is not aligned with the practices and objectives of the participants being evaluated and as a result will capture only tangential efforts and effects of their actions.

As we know from our conversations with the MCTIC (ANNEX 2) the information in the report first confuses all patents generated by the company with those generated by the IL mandated R&D funds. More importantly, from the same clarifications we confirmed that only patent applications were accounted, and that no subsequent monitoring verified if they were actually granted (ANNEX 2). As a third limitation, there was no distinction between what was in effect a patent and what would be a smaller registry such as a utility model; this is particularly relevant since in Brazil if one requests a particular entry as a patent and the Brazilian patent office thinks it is not innovative enough it can still register it in the same procedure as a utility model, but the reverse is not true, if you filed as a utility model and the patent office thought of it as innovative enough for a patent it will not be able to file it as such (ANNEX 2). Therefore, there is a strong incentive to try to classify the innovativeness of the filing upwards (PEREIRA 2011).

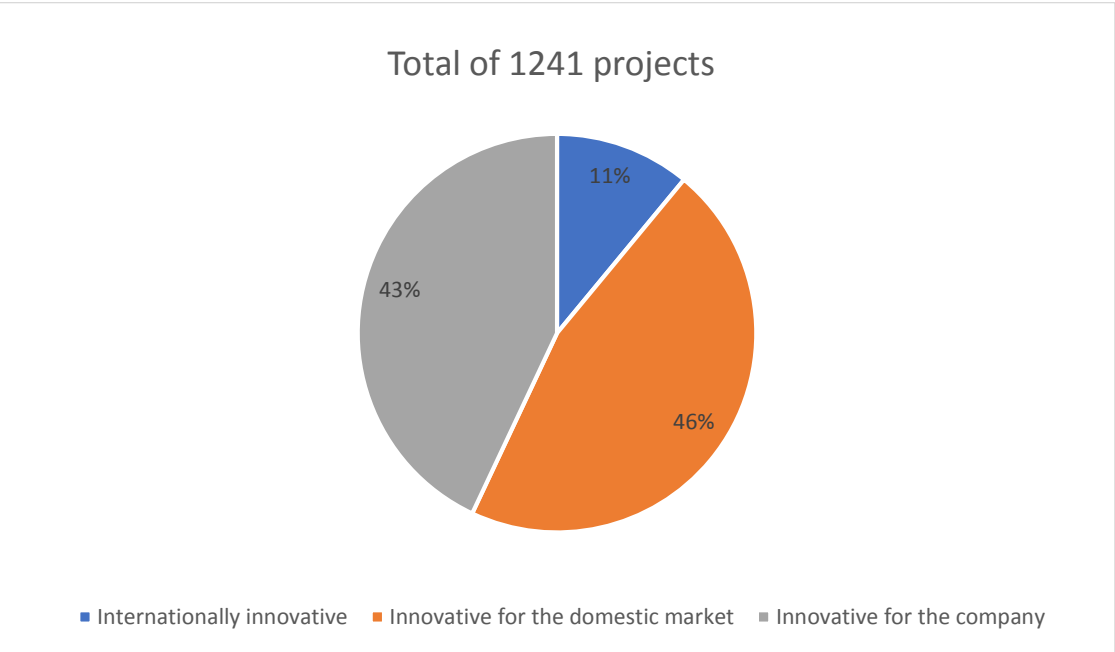
We refrain from utilizing this information further here because the MCTIC has been unable to expand the data by sector or provide any information about the

relevant patent. Given the near decade long delay in Brazil between the request and granting of the patent application, the lack of control of such rates of acceptance further weakened the usefulness of the indicator. Either the Oslo Manual, or a more direct informational approach would suggest a myriad of data points to be assembled from the reports. In their current form we can only significantly look at levels of expenditures in R&D, and that the growth in the level of expenditure has corelated to a small growth in patent applications and publications.

3.8 Frequent discontinuity of data

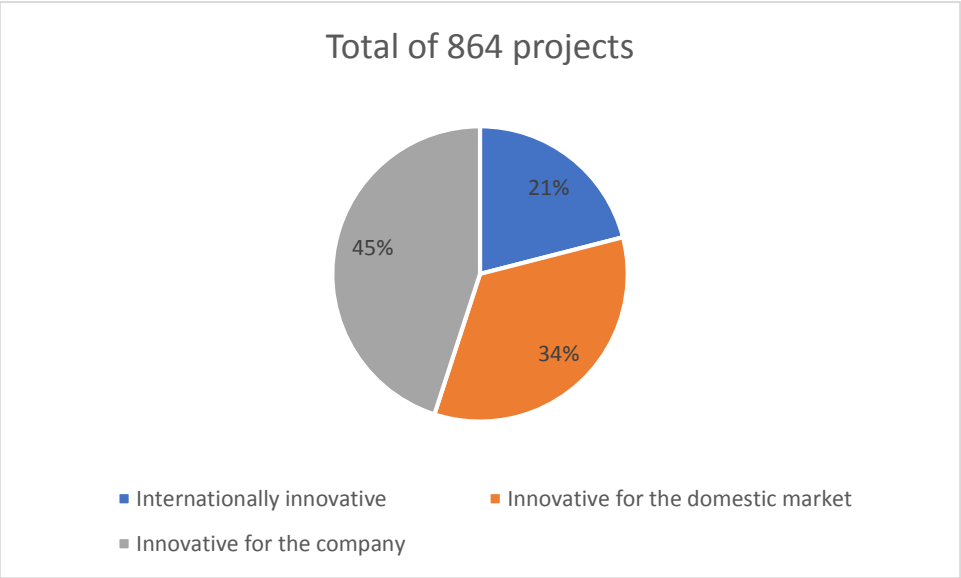
In an unfortunate pattern, we see a frequent discontinuation of presented data which prevents certain time-series analyses. Before the effective standardization of the reports around 2012 each reporting period creates its own data set and presentation, but without a continuity to allow for a longer analysis. This seems to indicate a lack of clear direction as to what was being sought in the data, and as a result a frequent change on what segment of the data was presented. For example, the MCTIC Report of 2008 presents an interesting pie chart on the nature of the innovation performed either by a project conducted wholly within the company (Figure 3.4) and with institute's as partners (Figure 3.5).

Figure 3. 4 Type of Innovation created by R&D expenditures by companies internally



Source MCTIC Report 2008 translated by authors

Figure 3. 5 Type of Innovation created by R&D expenditures with institutes and partners



Source MCTIC Report 2008 translated by authors

As expected, the vast majority of the innovation is (by self-description) an innovation for the company or for the domestic market. This data is no longer presented in any subsequent report, and neither was it present in any previous report. This form of discontinuity prevents certain conclusions that even if the data had some flaws (as self-reporting is susceptible to have) that could be overcome by their consistency in its collection over time. For example, we notice a substantial difference of in the internationally innovative aspect of projects with partners, if this proved consistent over time, potentially providing an argument for extending this type of expenditure if this is the form of innovation most desired.

A graver example of data discontinuity can be found in the nature of the technology of the resulting incentivized sale. The separation per year and per technological origin is extremely rich and useful for evaluating the efficacy of the sector in generating innovative products as we can see in Table 3.5. While this is not a perfect indicator to innovation, over time it would clearly become a powerful evaluating data point for evaluating the innovation component of the IL.

Table 3. 5 – Segmentation of type revenue by technology origin

Characteristics of the Incentivized Product - number of products	2006	2007	2008	2009
with patent	202	269	215	351
of domestic technology	817	977	1238	1420
of foreign technology	280	310	623	717
of domestic technology and patent	105	174	129	165
of foreign technology and patent	97	95	86	186

Characteristics of the Incentivized Product - Amount of Revenue in reais	2006	2007	2008	2009
with patent	2.757.290.987	3.327.672.242	8.143.374.159	7.515.191.709
of domestic technology	5.445.284.882	6.556.032.459	9.461.811.210	7.564.185.563
of foreign technology	10.484.024.405	14.261.126.845	15.367.994.375	16.004.112.824
of domestic technology and patent	498.265.158	570.421.009	3.375.233.950	369.658.364
of foreign technology and patent	2.259.025.829	2.757.251.233	4.768.140.208	7.145.533.345

Created by authors from the data of the MCTIC

Unfortunately, this data is discontinued in 2009 and is absent from following reports. Such data in a longer time series could lead to very interesting conclusion about the market growth of domestically developed products, and thus an interesting proxy both to the success of the law in fostering a vibrant domestic industry and of the effectiveness of the R&D expenditure in creating at least domestically competitive products. The final format of the MCTIC reports from 2011 onwards lose other considerable examples of data, creating a frequent tabula rasa regarding data acquisition. These frequent changes remind us of the observation made by Scheinblatt (1982) on the difficulty and the importance and challenge of generating comparative data for R&D productivity measurement.

3.9 A Potential new form of evaluating reporting

As a form to deal with the backlog of annual reports generated from the IL, a specific evaluating methodology was created in the format of Project AvalRDA. This formatting is finalized in late 2015 and places prominently in its introduction:

"The Methodology was conceived to consume the legacy composed…[of past reports] since 2006. Considering that the descriptive fields of the RDA are open and without restriction of the declarations by companies, and that the analysis must be performed by a collegiate of analysts, the scalability of the Methodology was a mandatory prerequisite for the Project AvalRDA" (Project AvalRDA pg. 3).

This is meant to act in conjunction with the instructions provided by the MCTIC (MCTIC Manual of Reporting), and clearly seem to partially address the critique by the TCU on a lack of standardized analytic methodology, that would allow both for a more consistent evaluation process as well as allowing for a better prioritization of resources placing the most auditing resources where (over time) the most expected errors were expected to be located (TCU 2014). This new Methodology is not in itself a radical departure over what could be gathered from previous reports, but it creates a different presentation framework for a more systemic evaluation.

The methodology itself is mostly a systematic grading system. It consists initially of a pre-analysis checking for basic comprehensiveness of all necessary fields. For what are considered strict R&D projects it proposes the evaluation of the following attributes:

a) Scientific/technical problem: As the project must seek to solve (partially our completely) some technical or scientific challenge.
b) Contextualization of stages: It should be conducted in a systematic manner, with specific activities.
c) Investigative Activities: The project must also include investigative, validation, or experimental activities that either validate or contribute to the result of the overall project.
d) Originality Element: The project must present how its results contributed to an increase in knowledge (as a better product, process, or any characteristic of result).

These attributes are to be graded in a level of Grade 3 (highest – best) to Grade 0 (lowest - not conforming). The Project gives general directions on how to consider each of the grades, but it creates only a very general direction, probably knowing that the practical reports will have a large variation of content and therefore only the most general directives would be applicable. This is followed by a specific grading scheme for expenditures on human training and development. There are only three evaluated attributes in that case:

i) Content: What specific scientific, technical, capabilities are being developed in a particular project.

ii) Complexity Level: Is the complexity level attached to this is directed at those with bachelor education or the equivalent of high-school education.

iii) Capacity or Formation of personnel: the personnel involved must be trained to act, or be in training to act, in an effective capacity in the information technology sector.

It is particularly relevant that a special grading schema is placed for elements of training and improvement of human resources. While it is historically an objective of the legislation, the data released both by the MCTIC and the ABINEE have traditionally focused on the industrial elements, particularly revenue growth. In all the data currently released there is no indicator to persons trained, courses offered, skills attained, or any similar element. One wonders if with a more specific grading of this element the MCTIC is intending to create new statistics regarding training.

Evidently, since this new format of evaluation is being created to deal with a backlog that goes back to 2006, if it creates no new information (which is unlikely) but accelerates an assertive process of evaluation and allows for the prompt publication of audited data it would already be an enormous improvement over the current situation. As we will see subsequently chapter 4.0 the retroactive application of these standards has produced a substantial practical difficulty for all the participants of the IL. The large degree of subjectivity of the new evaluating standard suggests that we wait for the publication of its findings for a more objective view of the quality of the new reporting being generated. We must remind ourselves however that we are already dealing with more than a decade of backlog to be re-published, which may substantially alter the current impressions.

3.10 Final Comments

As we have seen there are severe data gaps in the public, and even the internal available data of the MCTIC, regarding the economic results and growth of R&D resulting from the Informatics Law. Several authors have shown the relatively high costs of R&D in Brazil (ARAUJO 2010), and we can assume that

elements such as the Informatics Law, and the other elements of the Brazilian program to foster R&D are an important element to try to offset such challenges.

However, the mechanisms for monitoring and capturing results of the legislation have shown to have been mostly haphazard. The frequent discontinuity of the methods of evaluation indicates a lack of conviction on the nature of the data sought, culminating now with an extensive collection of data geared toward the amount spent and its geographical distribution. The very fact that in the early decade of the program the publication of results occurred erratically and sporadically speaks volumes of the importance given to data centric evaluation. The more than decade long backlog in analysis of the company and institute project data also suggests that the analysis of performance indicators of the expenditures generated by this program was not a priority.

Nevertheless, it is important to highlight that Brazil has experienced a growth in research expenditure, that has led to a general growth in the number of publications, formation of post graduates, and a general growth of scholarly output. This growth can in a small part also be a product of the expenditures of R&D generated by the IL. The lack of indicators doesn't give us the information that this increase in expenditure has had no effect, it only blinds us to the capacity to study in depth what that effect might be, and if its cost/benefit ratio is satisfactory.

It must be noted that while Brazil has improved its overall numbers on general R&D output, it has not narrowed the gap between itself and developed countries who also experienced growth in their R&D output (CORDER, 2006) (BASTOS, 2012). We could easily imagine with the data already in possession of the MCTIC, the development of indicators of profitability, domestically developed technology, domestic supply chain evolution, and a variety of indicators that would better evaluate the industrial policy aspect of the program. The innovation side of the program would also greatly benefit from a more detailed view of which sectors are innovating domestically in products, and what kind of innovation is being produced by the spent resource.

The limitations end up dominating our analysis since they are capped not only by the deficiencies in numbers, but also by the publication of numbers before the

analysis of the MCTCI, which has generally rejected nearly the entirety of the initial reports provided by companies and institutes. This casts a pale that not only our current indicators are not only parse, but also might be substantially different from reality once they are fully audited. Also, the delayed dataset available also predates the substantial economic crisis that Brazil has been through after 2016, and as a result drastic reduction both in public and private expenditures might mean that substantial different current reality than the limited view presented by the published data. The emphasis of the new reporting method indicates also only a systematization for auditing purposes, and not a fundamentally different way of presenting collected data.

With the final result of the WTO Appellate body being negative towards the IL, it is likely that the Brazilian government will have to substantially change its strategy for the continuing development of its electronics industry (WTO Panel report 2017, WTO Appellate Report 2018). It is unfortunate that regardless of the diligence in preserving a program for over two decades, a lack of data with inhibits analysis permits only the most basic insights towards failure or success of the current program in preparing the legislation for a more acceptable form of development for WTO standards. We are struck with a situation where the overall efficacy of a major obligation of the IL program is effectively unknowable. This is not due to a lack of academic interest in the study of the IL, or of innovation, but on the deficiencies of the data collection, analysis and publication of data that has spanned decades.

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4 - An analysis of the present situation of the Informatics Law through the prism of multiple sector players.

Abstract:

This paper summarizes interviews with 15 entities that currently utilize or are somehow affected by the Informatics Law (IL). The objective of the interviews was to obtain a variety of perspective on past, current and future impressions on the Informatics Law, and how the current uncertain environment has affected the players, their perspectives for the near future, and their current activities. Special focus was given to questions about their reporting with government entities that regulate the Informatics Law and their views with regards to some statistics created to monitor the IL by government regulators.

4.1 Overview of situation

Currently the final decision by the WTO released in December 2018 (WTO Appellate Body 2018) allows for an open timeline for a negotiated ending of the offending benefits afforded by the IL. The current situation is one of uncertainty as the strong likelihood of a major policy alteration looms in the horizon while companies and institutes must make strategic plans for the medium and long-term with this unknown in their strategic planning. We sought companies and institutes participant's in the IL seeking to validate some points raised by our analysis of the MCTIC data, and obtain their perception of our impressions and the general situation.

4.2 Methodology

We have conducted interviews with 15 entities that benefit from or are participants of the benefits of the IL law. Cognizant of the reticence perceived by Sergio and Porto (2012) in interviews about the IL that might raise offense to regulating authorities, we assured the anonymity of our interviewees' answers.

The breakdown is five institutes which conducts R&D projects originated by the obligations of the IL, a major college which also conducts R&D projects with funds originated from the external obligations of the IL (and also hosts IL benefited companies on its campus)- which for simplicity we will name institute VI, eight companies that are beneficiaries of the IL and utilize it heavily in their operations,. We will generally place both the university and the class organization under the label of “institute” for simplicity although it is not a legally apt definition for them. For future references the table below serves a reference marker (see table 4.1):

Table 4. 1 Composition of interviewees

Reference	Region / Sector	Size as per revenue (MCTIC criteria)
Institute I	Southeast	large
Institute II	Southeast	medium
Institute III	South	small
Institute IV	Southeast	medium
Institute V	Northeast	large
Institute VI	South	large
Company A	Electric, oil & gas	medium
Company B	Electric	small
Company C	CM	large
Company D	Telecom	small
Company E	Telecom	medium
Company F	Research	small
Company G	Banking Automation	large
Company H	Automation	medium

Source: Authors

The interviews were conducted on a conversational format, usually in person but on occasion by remote means. The vast majority of the interviews were recorded and transcribed, but some (6 of them) the subjects preferred not to be recorded and contemporaneous notes were kept of the conversations. The conversations were guided to reach the following questions, from a company perspective:

1. How do they perceive the current situation of the IL and the WTO decision?
2. How relevant are the benefits of the IL to the firm?
3. How would you characterize the future of the firm given a complete discontinuity of the benefits from the IL? How has this affected your strategic planning?
4. How do you perceive the need of geographic dispersal (north and northeast region) of the R&D obligation?
5. What objectives to you assign to your R&D projects and how does it align with the firm's objectives?
6. How do you measure success of your R&D projects?
7. How would you describe your reporting experience of R&D expenditures with the MCTIC?
8. How frequent has been the feedback of the MCTIC of the R&D expenditures reports?
9. What is the profile of the average person involved with R&D in the company?
10. Has the company generated any patents or academic publications recently? What is the company view on patents?

And adapted for the institute perspective:

1. What is the Institute's opinion on the current situation of the IL and the WTO decision?
2. How relevant are the funds from R&D obligations are to the institute?
3. How would you characterize the future of the institute given a complete discontinuity of the funds from IL? How has this affected the Institute's strategic planning?
4. Are there statistics on the type and area of R&D investment that can be shared?
5. What are the most common areas for R&D resources of the IL?
6. How do you measure success of your R&D projects?
7. How has been your recent experience of reporting R&D expenditures with the MCTIC?

8. How frequent has been the feedback from the MCTIC about their analysis of their reports of R&D expenditure?
9. What is the composition (age, gender, level of education) of the average researcher involved in R&D with the institute?
10. What is the average length of employment of the institute researcher?
11. How many academic publications were generated from IL resources? Do you keep a control of their impact factor?
12. What is the institute's policy towards patents?

The available transcripts show that at times the interviews flowed in such a way that some questions were spontaneously answered before asked, which at times makes the orders of the questions broached different in each interview. It is our belief that this in no form affected the format of the answers and was merely reflective of a natural flow of the interview.

4.3 Notes on limitations

While our interviewees (and ourselves) extrapolate several larger themes and opinions on the nature of the current situation of IL benefited companies and ecosystems, that must not be taken as definitive proof that such a perspective is indeed correct or an accurate presentation of reality. Not only the view of the interviewed might be skewed from a realistic perspective, but there are biases in our sample that must be mentioned.

All the companies in our sample have their operations in the southern region of Brazil. This can bias their opinion on several topics such as the geographic dispersal obligation within the R&D obligations of the IL law, whereas a firm already located on the North, Northeast region where such dispersals are mandated could have a very different opinion of the impact of such a dispersal obligation. Moreover, the companies interviewed range from very small to large sizes on the MCTIC classification of companies by revenue size; nonetheless our small sample skews to very heavily towards smaller and medium sized companies.

As regarding the institutes, the situation is more curious. Due to the fact that very large institutes were participant of the interviews (along with very small organizations) the share of institute revenue captured by the interviews is actually quite large. It should not be confused necessarily with statistically significant.

4.4 Results

Here we present the results from the interviews in eleven subsections. The first deals with the interviewees' perception of uncertainty in the medium-term planning horizon. Next, we broach some views on how to preserve some different sort of incentive made acceptable to the WTO standards. Subsequently we study the theme of innovation and R&D, both the subject's perception of the obligation and of their own R&D performance. In addition, we proceed with the interviewee's perceptions of patents and publications, both prominent indicators used in the MCTIC data. Finally, we conclude with how the interviewee perceive success in their R&D.

4.4.1 Uncertainty of the medium-term scenarios

All companies have expressed grave concerns over the uncertainty of continuous operations given the potential loss of benefits from the IL. Although the range of concern was varied it ranged from extremes of virtual certainty that the absence of incentives would quickly end their industrial operations to general uncertainty if the company project as a whole would be viable without some equivalent incentive to the IL.

Despite the potential consequences of the scenarios varying widely there was a common theme in that the uncertainty was so great as to transcend their capability of having a strategic plan to face it. As was mentioned by both company D and B, the range of possible outcomes from an abrupt cessation of benefits from the IL, to a gradual cessation, to eventually a substitution of incentives based on some new scheme that would conform to WTO rules precludes the ability to effectively plan for it. The companies are overall more focused on the incentives that would allow for greater competitiveness for

Brazilian manufactured products, the general perception is that without some level of benefit their respective market will be dominated by foreign manufactured products and they will either have to adapt to reconsider their domestic manufacturing capabilities.

The institutes present a very different view of the danger of the situation to their continuous operations. The vast majority of institutes have placed their dependency of funds originated by the IL R&D obligation as above 90% of their total operating revenues. The larger institutes (specially Institutes I and II) were adamant on the importance of the continuation of such obligations were for their operations. It should be noted that Institute II was specifically created to fulfill the R&D needs of a particular large-scale manufacturer that benefited from the IL, and thus would generate large volumes of R&D obligations whose external components could then be fulfilled by the institute.

Smaller operations, specially Institute III, were reasonably optimistic of their capabilities of seeking different forms of funding to continue their operations in the case of a total repeal of the current incentive and obligation structure without any replacement. In fact, Institute III was the only respondent who was capable of already reducing the share of IL R&D funds from their revenues to below 50%. It should be noted, however, that the revenues of Institute III are approximately 5% of the revenues of Institute II suggesting that smaller players can see a greater flexibility that might elude larger organizations with greater amounts of revenue to replace.

It is interesting to note that despite the current scenario of uncertainty in the past three years two companies in our sample (companies E and H) have invested in new industrial facilities geared for expansion. The timing of the Brazilian crisis after 2016 has made such growth delayed, the current uncertainty over the continuation of any form of benefit from the Informatics Law has generated a gap in strategic planning that reinforced a wait-and-see attitude.

4.4.2 Attempted Proposal of alternative benefits

An issue that was present in most of our interviews with companies, was the compromise position attempted by the class organization (which we refer to as Organization 1). The core idea of the plan was to provide a viable replacement scheme for incentives for R&D intensive firms predicting the absence of the current IL incentives. The proposal was being coordinated with the MCTIC and high levels of the Brazilian administration, but delays in the negotiations meant that they were increasingly dealing with an outgoing administration – especially after the presidential elections of 2018.

The core of the proposed change would be to create a new form of tax incentive in a reduction of the corporate income tax for companies that qualified with high levels of R&D investment. This would move the current incentive structure away from the value added-tax benefit given today – and found to be in violation of WTO rules and towards a reduction on income tax paid by the corporation. If this benefit could sufficiently compensate the loss of the added value tax benefit is questionable, and even in the interview Organization 1 recognized this. It would greatly depend on a per market competitiveness situation and the income tax hurdle faced by importers that would compete under the new situation.

More importantly, it would shift the benefit from a dual aim of incentivizing R&D and industrial activity towards a single goal of incentivizing only R&D activity. This would be clear since it would be difficult (if not impossible) to prevent legally that companies import products for the Brazilian market and perform the R&D to obtain the full benefits of this potential new law. It should be noted the WTO Panel itself mention in its findings that countries are allowed to incentivize their domestic producers, only not in forms that will treat the products differently according to the origin of their producer (WTO Panel p.170). More importantly, the WTO Panel itself found that the R&D obligation by itself was an acceptable requirement on the current IL for WTO rules since it could be performed by any company (WTO Panel p. 115). It remains to be seen if the political interest on preserving a solely R&D focused incentive program would be sufficient for the creation of a new incentive structure. Organization 1 believes that while they had convinced the outgoing administration, most of their job was undone by the

change in administration and that they would have to start their political efforts anew, additionally they assume that the incoming administration will have a political position disagreeable to such forms of incentives, but they concur that these were preconceived notions as the new administration had been very recently inaugurated when the interview took place.

The general view of interviewed companies is considerably pessimistic as to the creation of a different and WTO compliant form of incentives. They range from a very negative conviction (such as companies E and H), to a pessimistic wait-and-see posture (such as companies A and B). While such an issue remains unresolved, they have a very difficult strategic unknown ahead of them that impedes several instances of long-term planning.

4.4.3 The R&D Conundrum of Easy vs. Hard Obligation

Among the companies a quick dichotomy was apparent. Companies that were mostly engaged in the production of the products of others, most notably the Contract Manufacturer (CM) among our interviewees, found the R&D obligation a substantial burden and something of very difficult productive allocation. This had the effect of, on that occasion, making the R&D obligation into an effective cost – this was the case of Company C in our interviews. Meanwhile, companies that developed their own products, claimed to frequently far outspend the R&D obligation that the law required and saw it as mostly a minor burden in the obligation of communicating their effective R&D to the MCTIC annually. Companies A, E, and D explicitly stated that their activities would be impossible without their R&D expenditures and that the legal obligation had no effect in their decisions of level of investment, since they knew beforehand, they would far outpace the obligation.

In trying to understand this particular difference of perspective, our interviewee of Company C himself proposed a theory. He posited that to achieve even a low level of profitability in some competitive industrial operations in electronics one had to operate into much larger levels of economic activity than to operate in niche markets where you could tailor your own product and fulfill a niche specialty. Since the R&D obligation is tied to the level of revenue (and not

income) that the company generates from benefited products, to operate in large scale in a low margin market greatly diminishes the level of benefit derived from the incentive. More importantly, as interviewee of Company C mentioned, the level of technological difficulty of contributing to a cutting-edge global production process is far higher than the difficulty of perfecting a product for a national niche market.

This proposition being true leads to a bias in the IL benefit towards companies that develop specialized products for smaller scale applications as opposed to firms that focus on providing operational technological services (such as CMs, but including components manufacturers). Company C operates in the several hundred million of *reais* range, and nonetheless claims that to have any practical impact its R&D would have to be orders of magnitude greater, which is naturally impossible for their level of profitability. The resulting situation, for their particular case, is an R&D that has a very low level of productivity and tends to focus on bringing small scale innovations for ancillary aspects of the firm's activity as opposed to improving their core operations.

On the other hand, companies such A, B, D and H operate, usually, at a level of revenue below one hundred million *reais* and with far more specialized products. For example, both companies A and B have been leaders in their respective markets while operating below that level of revenue. Since all these companies sell their own products, they frequently have productive uses in product development for their own R&D that fall within an economic scope comparable to their obligation by the IL. These companies claim that since their core activity is so dependent on R&D they considerably exceed the obligation by more than 100% (special emphasis for company A, E and H on such characteristic).

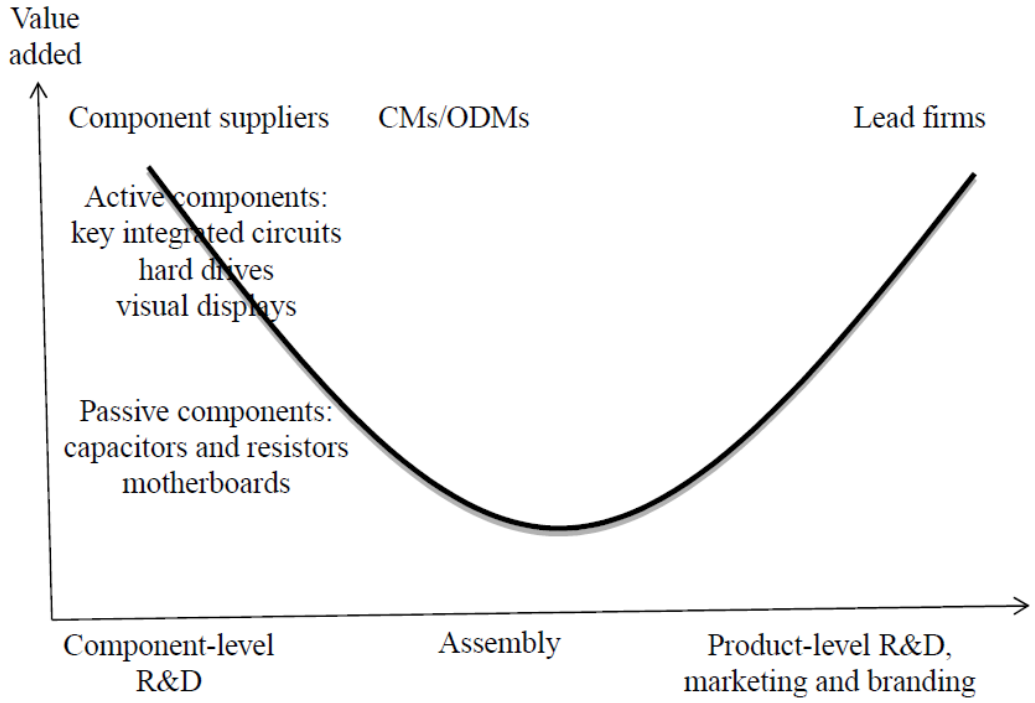
This, if true, leads to a perverse conclusion that while fostering a cadre of smaller niche companies with considerable domestic market presence, as opposed to larger scale electronic industry operations that would have stronger impact on current accounts and other elements raised by the proponents of the law (Prates, et al. 2006). It is important to note however, that this perspective

came from a CM firm, which are known to operate at the lower level of profitability in electronics industry. As research by Shin et al. (2012, p. 90) states:

> We find that lead firms and component suppliers capture more value as measured by gross margin and net margin, compared to various contract manufacturers (e.g. CMs/ODMs). We also find that active component suppliers gain higher profits than passive component suppliers 2 and that firms based in advanced economies earn higher value in terms of gross margins, compared to firms based in emerging economies. Our findings suggest that high levels of innovation, sales and marketing, and branding can build barriers to entry and help firms capture higher profits in global production networks.

As such, it is expected and known even outside the Brazilian context that it becomes increasingly important for profitability to allow for larger level of product differentiation. Shin et al. (2012) suggests a graphic of the "smiling shape" to demonstrate the profitability curve of the electronics industry placing the activity of assembly at the bottom of the curve (see Figure 4.1).

Figure 4. 1 Value added across activities in the electronics industry



Source: Shin et al. (2012)

Therefore, it is also possible that company C is simply in a low-profit market, and that regardless of the benefits of the IL it would be a poor vehicle for innovative expenditures in a capital scarce market such as Brazil. It is also possible that the Brazilian general level of high cost of capital makes for

unprofitable activities which require higher capital expenditures, and as such any additional obligation (such as the R&D obligation) is simply increasing the obstacles for an already difficult task.

It is important to note observing this that the core of the IL law is centered on controlling which assembly activities are performed domestically, the inclusion of services that create markets for specialized suppliers (be they of specific electronic assembly services or purchases of specific types of components from domestic sources) were at the core of the WTO complain against the IL (WTO Panel Report 2017 p.66). The WTO Appellate Report fundamentally concurred with this decision, creating a strong pressure in Brazil to alter the law as to adhere to WTO legislation (WTO Apellate Body Report 2018) Therefore, the proposed solution by Organization 1 would in effect be probably insufficient for a company such as Company C who is dependent not necessarily of a particular tax benefit per se, but of an obligation that a particular industrial process be performed inside Brazilian territory. Company C was uncertain if any new scenario that lacked the production obligation would be sufficient to preserve an economically viable level of operations.

4.4.4 Innovation versus Integration

Companies D and F raised an interesting point of the innovation perspective claiming that their R&D could be better described as integration than innovation. Meaning while they rarely created a wholly new implementation, they would combine the innovation of others into a product more adequate for a specific application, normally making alterations to better adapt the product to peculiarities of the Brazilian application's environment. Such adaptations have been fairly common in all types of products for considerable time as traced by Still and Hill in several consumer goods, pharmaceutical and other products (Still; Hill, 1984).

Nevertheless, we found interesting the low-key, and in some ways self-effacing, perspective of such firms that their gradual innovation is a lower order of innovation. They were adamant in placing concepts such as innovation in the real of new implementation from a worldwide perspective, whereas we have seen

in academia much broader definitions of innovation both from the importance and advantage of a granular approach of micro innovations (Teece 2007) to innovation on how to tackle a business model and industry progression even when specifically applied to electronic industries (Everett et al. 1999).

We were unable to find a similar pattern of behavior in any of the other interviews, but the notion that the majority of the innovation was an innovation "for the firm" or at the most "for the domestic market" was also present in the interviews with companies B and A. However, they both presented an additional paradigm in that the core of their innovation was to produce a product that would achieve a similar goal but with a much lower production cost. Company B even used the concept of "frugal innovation" in our conversation as a core proposition of their innovation.

Their familiarity with the term was from the newspaper The Economist who ran a cover story on the term in April 2011 (Economist, 2010). The term is most widely cited from the Zeschky et al. (2015) and encompasses the idea a of product that is "good enough" while being considerably more economical and therefore far more adapted to resource strapped economies. In conjunction with the difficulties perceived by CMs on the previous section and the product profile of the companies in our small sample that were more satisfied with the IL benefits, it would indicate that the structure of the incentives and market conditions favor companies that indeed seek gradual frugal innovation over their own products as opposed to massive investments for large scale competitive electronic production.

4.4.5 The Rejection of R&D Reports by the MCTIC

Our interviews found an unanimity in that the MCTIC has recently rejected large portions of the reports submitted reporting R&D activity over the past 10 years. All of the companies reported that over 90% of their past 10 years of reports were recently rejected and a new set of guidelines for presenting the R&D expenditure presented and retroactively applied as to how they should substantiate the adequacy of an expenditure as R&D. The effect is that over 90% of their R&D expenditure was deemed either not to be actually R&D or to be insufficiently substantiated to be counted as such.

This subject was a considerable sore point for all of our interviewees who saw the rejection of their reports as something due a mismanagement of data and miscommunication by the MCTIC who remained silent in what was assumed to be approval. The idea of retroactively applying a new reporting standard to expenditures that are now years old and of great difficulty to procure additional documentation was of particular salience to our interviewees.

The consequences of a rejected report can be quite extreme, since in effect that means that particular R&D expenditure doesn't count towards the obligation. If a company is found to not have fulfilled its R&D obligation, they have two options: pay the amount they are short of their obligation to a special government fund, or be fined the amount of taxes that the IL benefited the company. Naturally since the tax reduction is considerably larger than the R&D obligation the choice is clear. However, once a report is rejected the company has an appeal process were, they can attempt to provide further information and hence substantiate their claim that the rejected expenses are in fact valid R&D expenses. This last path was the one taken by all our interviewed companies, since their reports included their expenses with institutes and third parties it launched them into a very large administrative task of seeking additional information of past expenditures.

Company D gave an illustrative example of the challenge, a rejected travel expenditure. Originally, they had merely informed the expenditure of the trip as part of an R&D project and attached corresponding fiscal documents proving that the expense took place. The new guidelines require that be additional statements such a statement of the purpose of the trip, prove as to who travelled, and specifically what was achieved towards the R&D project with the trip. All these items would be merely additional data if they were known and collected as the expense was taking place, but the effort to backtrack and collect that information years after the fact was quite resource consuming for all involved. Institute III mentioned they assigned a person exclusively for this sort of support for an entire year in order to provide information for the several companies that used the institute services as they required additional information for their reports.

Other companies expressed the conviction that this was an incredibly unproductive and reflective of the MCTIC trying to recoup a past mismanagement in analysis and data retention with a general refusal and creating the need for a refilling of all information. Companies B, D, and H specifically felt that some of the rejection showed signs of automated process that a simple reading would have prevented the rejection. The appeal process with the MCTIC was in all cases considered arduous and stressful, and several companies who exceeded the obligation values of the LI in their normal operations choose to spare manpower and appeal only a sufficient amount to cover the obligation of each year and not go through the appeal process for their R&D in excess of the obligation. If this behavior is carried in the same manner by companies outside our sample of interviews, it strongly suggests that future numbers of R&D generated by the IL will considerably undercount part of the R&D of companies of this particular profile that exceeds is obligation.

It is telling of the difficulty of the MCTIC in dealing with the information's in the reports that so late into the program they are still massively rejecting large backlogs of reports. We cannot be certain as to how the ministry will react to the additional information sent by the companies who hope to revert the rejection, the companies express hope that the ministry would be lenient in their reading being aware they were retroactively creating standards that would have been better met if known beforehand. Company B was exceptional in such case assuming the current recurse procedure was merely pro-forma and that the final result would be a rejection of a considerable number of reports.

It is also intuitive that the scale of the R&D of each firm creates a standard for the challenge involved in tracing back additional information. Since our sample is dominated by mostly small and medium firms, this behavior of massive backtracking of information might be a route taken by a large number of firms, but not necessarily by a large volume of the R&D obligation – since larger firms would have a larger challenge in chasing down a greater volume of expenses. Unfortunately, the ministry refuses to release data on how much of the expenditure is liable to be accepted upon this appeal, and therefore the best information we have at the moment is that massive amounts were rejected

placing a limited value on the aggregate amount of R&D expenditures statistics released by the ministry on their annual report.

4.4.6The internal market size theory as a means of scale

A core principle on the idea behind the IL is that the domestic market can serve as an incubator of sorts for increasingly efficient industries, creating a tax structure which allows for a competitive advantage for companies engaged in domestic production (i.e. following the production process mandated by the IL) of certain activities. The concept, as expressed by the MCTIC, is to create a competitive industry capable of generating personnel dealing with high end electronic technology, and effectively help finance investments in R&D with private funds. As quoted from Prates, Silva e Junior (2006, p.3):

> The need to strengthen the national industry capabilities of the innovations of products and processes in the Information Technology sector has led the Brazilian government to create mechanisms of promoting investment in research, development and innovation R&DI with a greater participation of the private sector. …. Such mechanism [the IL] beyond promoting a process of intensive innovation in the sector, which contribute to the expansion of the informatics industrial scale, generated qualified jobs, and stimulated the diffusion of information technology as a form of modernization for other industrial and service sectors.

Naturally the equation is only economically viable if the incentive structure generates sufficient benefits to entice the private sector to perform accordingly. The contention of Company C is that the Brazilian domestic market (all that can effectively be affected by the effects of the IL) is insufficient for what are truly efficient scale of operations for international competitiveness on large scale products. In the view of Company C, a partial market-share of a market that is less than 5% of the global market will not allow you to compete competitively abroad. As a consequence of this premise, Company C sees the IL structurally set up for operations that are either small or perennially dependent on it. From their perspective the successful path to a truly competitive electronics industry would be what they conceive as a similar program to the Korean example where the government not only created an incentive structure for innovation and electronic activity but heavily capitalized the sector – as opposed to burdening it with obligations for R&D which are fated, in their view, to mostly low results.

One data point that reinforces the view of company C is the dominance of global products in the production of incentivized goods by the IL. As we can see from the data of the MCTIC, the share of incentivized production captured by personal computers, tablets and cellphones tends to hover around 70% of the total production (see table 4.2). Taking as a premise that cellphones, tablets, and personal computers are generally global products, it would indicate that more than half of the production incentivized by the IL is dominated by companies more similar in profile to company C – i.e. manufactures of products developed abroad – than the rest of our sample of interviewees who generally develop their own products.

Table 4. 2 Composition of revenue benefited by LI segregating Cellphones, Personal Computers and Tablets.

Year	Personal Computers and Tablets	Cellphones	Others	Total	% Cellphones	% Personal Computers and Tablets
2013	R$ 14.262,55	R$ 13.150,98	R$ 14.465,31	R$ 41.878,84	31,40%	34,06%
2014	R$ 13.240,51	R$ 17.751,33	R$ 15.612,46	R$ 46.604,30	38,09%	28,41%
2015	R$ 17.599,21	R$ 17.751,33	R$ 11.348,61	R$ 46.699,15	38,01%	37,69%
2016	N/A	R$ 18.098,68	R$ 23.965,92	R$ 42.064,60	43,03%	N/A

Source: data from MCTIC compiled by authors

It should be noted that the majority of other companies in our sample have relatively small export presences making the domestic market size element particularly relevant, with two substantial exceptions in companies G and H. Both companies G and H have considerable percentage of sales abroad, and company G has recently expanded with a production facility overseas. Their answers, specially for company H, were not substantially different from other companies; nevertheless, they both expressed a diminished fear of losing viability in the case of a full repeal of the IL while maintaining that some form of incentive is crucial for the competitiveness of their domestic operations. In a more elaborate answer

company H posited that importers have a far greater flexibility to find the best state from where to import and seek transient tax advantages that would in effect place domestic production in a competitive disadvantage in the domestic market.

In an ancillary benefit of expanding beyond the domestic market, company H mentioned that it created a natural foreign exchange hedge for their operations. Since electronic components are purchased overseas, they generate an account payable in dollars with exports they have account receivable also in dollars of a similar if not greater volume, not having therefore to incur in a substantial foreign exchange risk or have the cost of a financial hedge. It seems a case of self-reinforcing efficiency.

4.4.7 The Geographic segmentation of the R&D obligation

The IL demands that a fraction of the R&D obligation be spent with institutions in the North or Northeast regions of the country. The stated objective is to increase the capabilities of such regions as the southeast region of Brazil has been historically the most technologically advanced one. Generally, the views of the companies we interviewed were negative with regards to the results obtained from R&D funds with mandated allocation to institutes in the North and Northeast.

The reasons given for such opinions however varied widely. Company A and C saw is as a generally inefficient use of resources due to the fact that since we are already struggling to catch-up it is impractical to expect that in the midst of this effort to help another further behind to do the same. Company B saw the greatest problem the fact that their costs were higher considerably higher (between 50% and 100%) than comparable work in the Southeast, therefore cost being the greater factor for the perceived inefficiency. Company D and F saw it as effectively a cost since the low returns obtained but could not elaborate if their perception was a quality or cost issue (if not both). Companies E and G saw it as a reasonable tradeoff of a small loss of productivity in R&D expenditure for the overall program to be politically viable. Company H claimed to have always failed to obtain good results from such mandated long-distance partnerships but wondered if this wasn't due to some inability of their own to manage such projects

efficiently from a distance – noting specially their success in projects with local institutes and universities.

4.4.8 Intellectual Propriety – a surprising non-issue

Our interviews found an unanimity in that both companies and institutes had very little interest in patent requests. The common cause given by the companies were two-fold, companies D and F believed that the truly valuable work they performed was in what they encompassed by integration and therefore generally not innovative enough to obtain patent protection; all companies (including D and F) also mentioned the large delay in the Brazilian Patent Office (BPO) in analyzing and granting patents which stands at multiple years. Local press confirms the average delay between requesting a patent and having it approved in Brazil stands at nine years (PEREIRA, 2011), which (in the opinion of our interviewees) would place their innovations as obsolete by the time they were finally granted a patent.

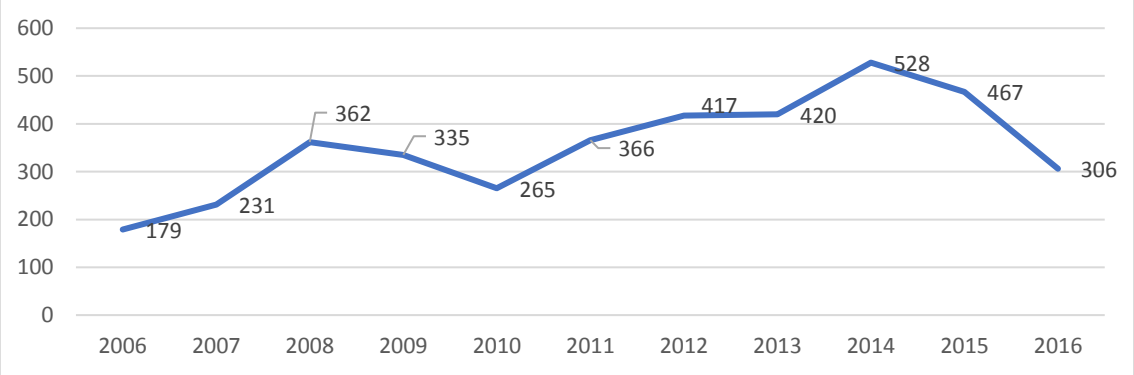
As a result, the firms in our sample have none (or single digits) applications for patents regardless of the fact that several operate with proprietary technology. The product cycle being in some cases more relevant than the patent protection places the emphasis on being more economical and having a better time to market than a large collection of protected proprietary technology. This is particularly telling as several companies with their own developed products see little to no value on patent protection citing both the difficulties of the very slow patent process and a slow judiciary for later disputes. Some companies have begun approaches for obtaining international patents for their newer products, but are still unfamiliar with the legal terrain for such activities.

The institutes provided a different perspective. The institutes would waive any and all rights to the technology they were developing in order to foster a more cooperative and friction free collaboration with the firms. In our conversation with university 1 they recalled a regional case where there actually was intellectual propriety sharing agreement between university and firm, a patent dispute brought an overall drop in interest of firms in partnerships were there was any royalty sharing to a standstill. Since that time their policy had been of waiving such rights, which incidentally created a competitive advantage for the university

1 against the local federal public university since the public university found itself barred of waiving such rights as well. All interviewed institutes maintained the position of waiving any royalty rights, and also mentioned those rarely would have been relevant anyhow due to the policy of most local firms against patent protection, while multinational firms would be so vigilant against such agreements that it would be administratively too onerous to try to create them.

In this scenario of few patents being filed and of institutes being dismissive of royalty revenue one can wonder at the decision by the MCTIC of keeping track of patents generated by the R&D mandated by the IL. This data gathering by the MCTIC began in 2006, but unfortunately it only tracks patent applications, and as a result of the large delay we cannot know which were in fact granted or not or even of what each application requests were permitting others to follow through (and the MCTIC doesn't track that information) (ANNEX 2). As we can see below the number of patents generated by IL R&D funds is not large and even a complete tracking of their situation would be possible if more information on them were available (See figure 4.2).

Figure 4. 2 Patent Fillings from IL R&D Funds



Created by authors from MCTIC data

The limitations of the informational value of a simple count of patents as an indicator is well known and frequently dealt with in academic literature. Trajtenberg (1990) proposed to weigh the count with the citations each patent receives as a form of distinguishing more relevant from less relevant patents. In the case of patent citations these occur when each new patent is filed other patents are referred to as prior influences and to explain their current innovation, the more a patent is cited (supposedly) the more influent it is. Duguet (2005) has

shown that patent citations can be a statistically relevant indicator of a firm's technological acquisition and dispersal of technology. Nonetheless with such a small sample size of patents as we encounter in the results of the IL it would be difficult, if not impossible, to perform such analysis as the difficulties with the backlog on granting patents has altered considerably the local behavior compared to Duguet's French ecosystem.

The totality of the interviews suggests that the difficulties and delays of being granted a patent in Brazil greatly diminishes the interest of companies in effectively filing patents, suggesting that there is quite likely an undercounting of effective innovation being produced by the IL R&D resources when using this metric. The institutes prefer to preserve their relationship with the companies and relinquish any intellectual property rights on their projects as a way to defuse any potential future dispute with their hiring company. On the negative side, the delay forces us to work with patents filed as opposed to granted, also potentially damaging the quality of the information gathered and potentially leading to a count of patents rejected as innovative when eventually processed.

It should also be noted that a there are arguments to be made that an open innovation environment can be more conducive to innovation. Chesbrough (2003) elaborates on how several innovative companies can apply principles of Open Innovation and combine internal and external ideas to the combine in potentially more efficient and vibrant mode of innovation, naturally the absence of intellectual propriety barriers would accelerate (or at least remove a possible impediment) to such innovation mode.

4.4.9 The Small Academic Publication Focus

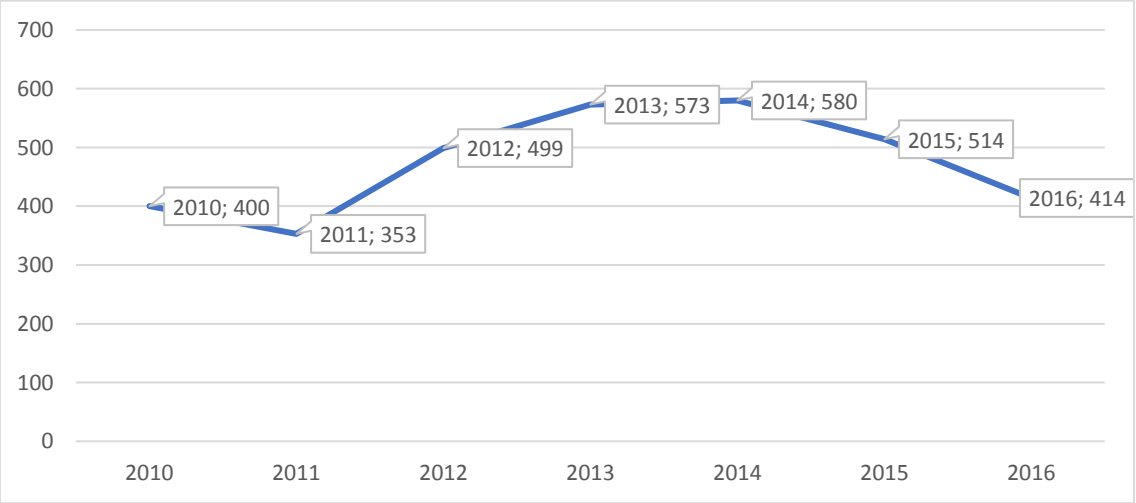
Another statistic tracked by the MCTIC is the number of publications generated by the IL mandated R&D funds. On this matter all the firms showed a natural disinclination as they mentioned that they lacked any economic interest in academic publication. While we do see some of them having employees that did undergraduate or graduate academic work around their operations, they had no statistics if any such studies were ever published. A consistent answer was

that academic publications were not in any for within the company's interest in their R&D expenditure.

The institutes were similar but more nuanced situation, institutes I,II, IV, and V mentioned very few if any academic publications as direct result of the IL projects since those were usually tailored for their clients specifications which rarely (if ever) would expect such result. They do conceive that since some of their researchers are graduate students some publications may have occurred in parallel to the actual project if the client authorized but they lack any statistics on that. This was very similar to the answer given by university 1, but in their case, they remembered they had a substantial incentive to publish in academic journals since the ratings by government entities of their graduate programs are heavily reliant on academic publication. The exception was institute III whose personnel had produced a few published articles (which incidentally resulted in a professional opportunity overseas for one particular researcher).

Nevertheless, the tracking of claimed publications by the MCTIC report predictably results in very few claims of publication. The fact that this is a tangential focus of even the institutes in their IL funded R&D projects suggests that this particular statistic is of little value in evaluating the efficacy of the R&D generated. We can see on Figure 4.3 that despite the growth on R&D funds resulting from the increase in revenue benefited by the IL we see practically no growth in publications generated.

Figure 4. 3 Publications generated by IL R&D Funds

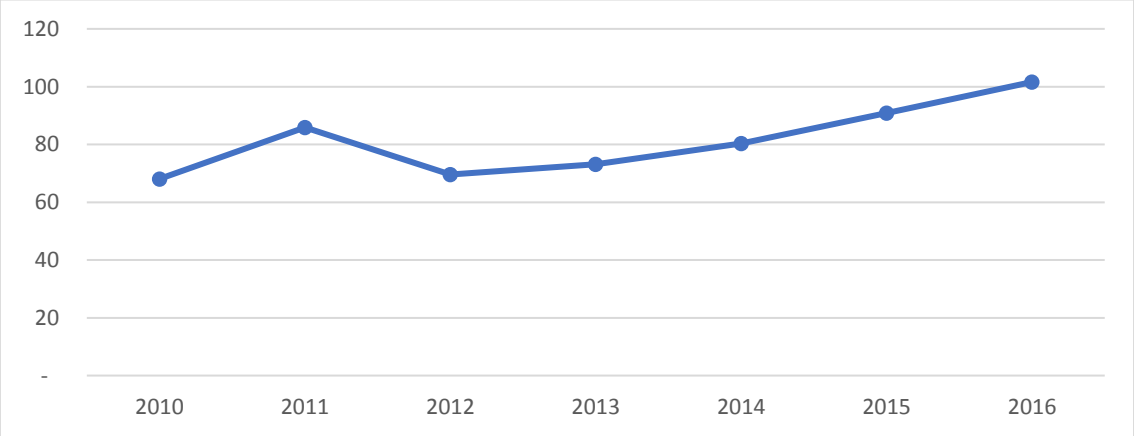


Source: Created by authors from MCITC data

This should not be considered a wholesale endorsement of impact factor as a perfect measurement of an article's value; several authors have commented on the limitations and potential pitfalls that impact factors can have as an analytic tool (as an example of such questioning we refer to Neylon and Wu (2009)). However, the absence of any study of impact coupled with the inability to lists the publications themselves puts us in an incredible precarious position to in any way validate or study the value of the publication created, to the point that the preservation of a time series of such quality becomes of highly questionable probative value (ANNEX 2).

When we place both Figure 4.2 and Figure 4.3 in a comparative scale with amount of R&D generated by companies, we a decreasing return of productivity on the generation of publications (see Figure 4.4) while a relatively stable (but also decreasing) productivity on patent generation (see Figure 4.5). These both contrast with a growth in publications and general patent creation in Brazil over the similar period, indicating that the companies and institutes involved in the IL are particularly unfocused on such metrics.

Figure 4. 4 Value of Incentivized Goods Sold per publication generated with IL R&D Funds

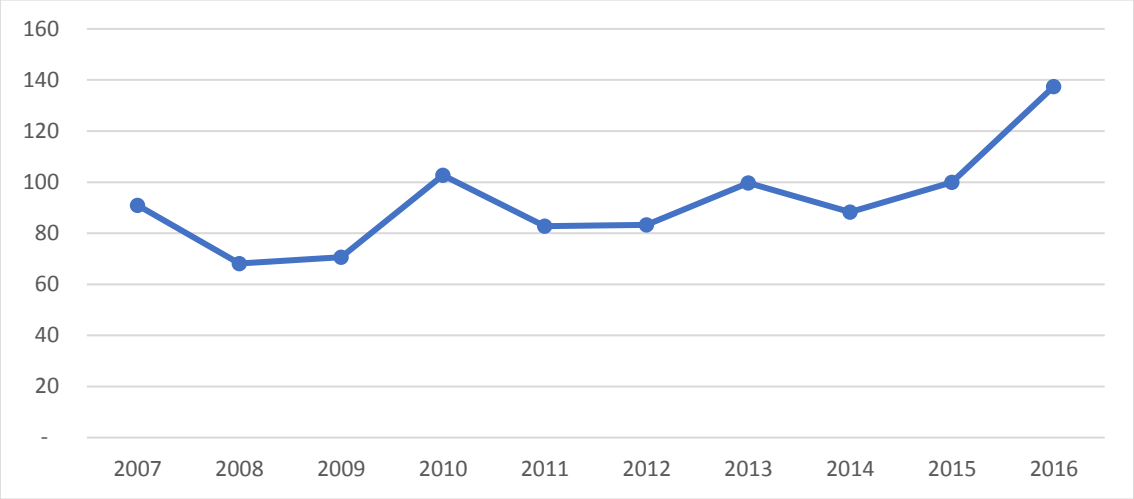


Created by authors from MCITC data

It must be specially noted that the economic crisis that Brazil entered after 2016 impacted considerably the amount to of incentivized goods sold which fell approximately 10% with regards to the previous year. As a result, a spike is to be expected on the year of 2016 due to the general fall on the total value of goods

sold that would not reflect in an immediate decrease in R&D as previous year obligations are still being carried over in the first trimester. Such a spike is more visible in the data for patent fillings, where the general trend of patents filed per amount of incentivized good sold is also increasing.

Figure 4. 5 Value of Incentivized Goods sold per patent generated with IL R&D funds



Created by authors from MCITC data

The low priority of publications is rather easily explainable in the difficulty inherent in academic research, however while the relatively low number of patent filings can also be an indication of the validity of the points raised by Companies D and F regarding the nature of the innovative work being more focused on an integration and adaption of already existing technologies that aren't as apt for patent filings as other types of innovation. In this case it is regrettable that more the MCTIC has not continued more general information on the nature of products sold and if how (and if) they enjoyed patent protection as was partially done through 2006 - 2009 and discontinued.

4.4.10 Brilliant High-schoolers

A peculiarity in the MCTIC data mystified our interviewees, when asked about the composition of their R&D staff as related to educational level the answer was always in the high nineties of percentages. Companies A and D mentioned that if we disregarded interns (as they usually did for their reporting due to the nature of internship work) the percentage might even be one hundred percent college educated (or higher). The institutes were even more adamant on such affirmations, also providing statistics of high percentiles of their R&D staff

with post-graduate degrees. Nevertheless, when we see the aggregated data by the MCTIC we see a different picture.

The MCTIC gathers all the collected annual reports[7] and produced a total aggregate where those with the equivalent of a high-school education fluctuates at around 30% of the total quantity of persons involved in the R&D activity (see Table 4.3). The MCTIC makes a caveat on a similar data from institutes (which results in a lower but also significant percentage of non-college educated on R&D) that the same person can be accounted multiple times by working on multiple projects. There is no reason to believe that those with lower levels of education would be involved in a greater number of projects than those with college education, but if that same caveat is applicable to the data of companies, such an event could skew the inferred percentage.

Table 4. 3 Composition of Human Resources (HR) by level of education

HR in Companies	2006	2007	2008	2009	2010	2011	2012	2013	2014
Total HR companies	55.388	70.221	85.087	96.814	112.397	127.996	124.501	134.295	130.092
HR with college education	13.802	15.055	20.142	22.843	27.984	33.662	33.007	31.983	37.906
HR in R&D	4.108	5.261	6043	6.746	7.244	8.068	7.994	8.122	8.436
HR in R&D with college education	n/a	n/a	n/a	n/a	4.996	5.590	5.644	5.891	5.896
Inferred HR in R&D without college education	n/a	n/a	n/a	n/a	2.248	2.478	2.350	2.231	2.540
Inferred HR in R&D without college education as % of total R&D HR	n/a	n/a	n/a	n/a	31,03%	30,71%	29,40%	27,47%	30,11%

Created by authors from MCTIC data

In a continuation of a pattern of non-standardization of data, the information from institutes human resources is presented in a different format allowing for a differentiation of direct and indirect involvement with the project. The current reports don't provide the methodology of taxonomy of indirect involvement, which allows for different standards to be used by different

[7] Temporarily disregarding, here, the discussion of the wholesale rejection of the reports noted by our interviewees.

institutions and skew the resulting data. Nevertheless, the pattern of a strangely high-level of involvement by non-college educated participants of R&D in institutions. Although the percentage is relatively small, there is an expected reduction in the percentage of participations among indirect participants with only a high-school education as opposed to direct participants (see table 4.4). This result is so discordant from the interview responses, and from what an expected result would be, that we can presume that there is some skewness in the data that is unexpected.

Table 4. 4 Participation in R&D Projects

Year	2011	2012	2013	2014
HR Directly Involved College Educated	7.459	8.464	8.278	8.983
HR Directly Involved High School Educated	2.115	2.158	2.454	3.210
HR Indirectly Involved College Educated	2.897	2.250	3.106	2.775
HR Indirectly Involved High School Education	674	780	721	651
Percentage of High School Education Directly Involved	22,09%	20,32%	22,87%	26,33%
Percentage of High School Education Indirectly Involved	18,87%	25,74%	18,84%	19,00%

Created by authors from MCTIC data

It is regrettable that this information is only available as headcount of personnel as opposed to amount of capital spent. By looking into amount invested we could easily correct for multiple account of personnel through multiple projects and have a more appropriate view of the impact of IL on human resources. We know from our knowledge of the format of the reports filed to the MCTIC and from our interviews that this information is available along with others for the MCTIC database, what remains is the methodological rigor to compile it over time (specially once resubmitted) and made public for analysis and discussion.

4.4.11 A View of Success

An interesting response the interviews collected was on how each entity measured (or in any way considered) a particular R&D project successful. The pattern was repeated in that companies consistently gave one answer, while institutes consistently gave another. Companies in all but one case, considered a particular R&D project successful if it was generated (or improved) a successful commercial product – and moreover that the scale of the success was comparable to the scale of sales generated by the resulting product[8]. Institutes and universities on the other hand had a view more consistent with client (in this case company) satisfaction, firstly they considered if the original specifications and deadlines were achieved, secondly, they considered if the client itself was satisfied with the result. The ultimate view from the institute's perspective was on client retention and a measure of competency and success echoed by the institutes we interviewed was in establishing long-term relationships of R&D for a same client.

In a particular way it is a similar commercial view as the companies, but they lacked the commercial data of products sold and since they rarely dealt with an entire product within their own specific R&D project, they used client satisfaction as a proxy. It is interesting that while the institutes showed a very strict view on finishing their projects on budget and a deadline (specially Institutes I, II and III), the companies didn't manifest any view of those variables as measures of success of a particular R&D project. Company H was particularly proud in fact of a particular initiative they sought of a more skunkworks style group they kept within the company and produced interesting results.

It must be noted that the focus on product development by both institutes and companies ended up ignoring elements of training and human development, which not only are acceptable expenditures within R&D projects but they can represent a result that transcends the commercial results of a resulting product

[8] The exception was company C, they lacked historically a product of their own (acting as a Contract Manufacturer – CM) of others, and as of now were involved in the assembly of products whose underlying technology they do not master. As a result, their R&D is in general considered less productive and more centered on the needs of improvement of their immediate industrial processes. In their case they claimed to lack any metric for the success of a particular R&D project and generally considered such an obligation a cost for the company.

from a project. This perspective also reinforces the view presented of Integration vs. Innovation above, in that none of our interviewees addressed purely exploratory projects, or technology reviews, or less directly applicable projects. The focus, in our sample, was clear in product application – this was both among our interviewed companies as institutes. Even the skunkworks segment in company H was directly connected to product generation. This is expected in a capital scarce environment where firms prioritize their funds to their most immediate and pressing needs of keeping their products current and competitive, but it clearly illustrates that the statistics chosen of patents and published studies are not proxies of the efforts undertook by the beneficiaries of the IL.

4.5 Conclusions and further studies

Our interviews reveal an entire entrepreneurial and innovation ecosystem dominated by a strategic uncertainty. The combination of an upheaval in the continuation of the law coupled with the start of a new government with potentially a different economic philosophy has generated a compounded uncertainty. Both companies and institutes remain in standby for the definition of a new and more definitive regulatory situation.

The continuing uncertainty can in itself damage the ecosystem, as all involved entities in general delay pertinent strategic decisions as long as possible – if not beyond that. We have however captured some unanimities with our interviews, all participants were aggrieved by the MCTIC wholesale rejection of reports, ascribing to the rejections a character that it is the result of the delay in analysis and the criticism of the TCU than actual rejection. They deplored the extra work and risk involved and lamented it as a wasted cost. Also dominant was the view of the low usefulness of patents in Brazil, always mentioning that the delay in granting the patent meant the products would be obsolete by the time the patent was effectively granted, giving it very limited practical use.

The institutes were perhaps the most surprising result, with a profound view of client satisfaction. They consider themselves service providers in a market for expert development services for products, and measure their competitiveness accordingly. As a result, publications were far removed from their priorities, unlike our *a priori* expectation that they would be more focused on

publications and academic pursuits. From our limited sample, it seems that institutes are successfully bridging academic environment where they gather their human resource and the corporate environment where they provide services. They also manifested the largest insecurity regarding their ability to continue their operations in the case of a cessation of the R&D obligations of the legislation. While private companies mostly considered if their industrial operations would remain viable and domestic, the larger institutes saw no comparable form of revenue to complement the shortfall.

An additional point of concern is to what extent the obligation of R&D expenditure is creating additionality in expenditure. As we heard from several companies, they consistently surpass the obligation requirement as a natural course of operations if they operate with their own developed products; and the case where additionality is more evident, in the case o company C they themselves saw the least value in the R&D they spent due to the obligation.

Therefore, the major takeaway is that a company with the profile of company C, a contract manufacturer that makes similar consumer products than are made worldwide but for domestic consumption has provided substantially different answers. They see their R&D as of very little use or result, in effect a cost, and see the fiscal incentives and the overall structure of the IL as paramount for their viability. Although the smaller companies that composed most of our sample represent the majority of companies benefited by the IL, the majority of the revenue generated comes from companies more similar to company C. A new round of interviews with a sample exclusively of companies of this profile will capture a much more substantial share of the revenue impacted by the IL and, if consistent with the answers of company C, paint an entirely different picture of the efficacy of the R&D obligation as a tool for driving innovation.

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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