Research and development spending and economic regulation: An analysis of companies listed on Brazilian Stock Exchange [1]

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Research and development spending and economic regulation: An analysis of companies listed on Brazilian Stock Exchange [1]

Regulamentação econômica e o gasto em pesquisa e desenvolvimento: análise de empresas listadas na Bolsa Brasileira

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Abstract: The objective of this paper is to verify if companies of economically regulated markets are discouraged to invest in research and development (R&D). Panel data analysis has been performed on a sample of 55 companies listed on the Brazilian Stock Exchange (B3), which published information on the amounts allocated to Research and Development (R&D) activities. The sample period comprises the years 2009 to 2014. Results show that regulation did not reach statistical significance in relation to the level of expenditure on R&D. However, we confirm the effects of certain characteristics of companies, such as size and performance, on R&D activities. These results may contribute to the formulation of public policies aiming at economic development.

Keywords: regulation, innovation, research and development, Brazilian Stock Exchange (B3).

Resumo: O objetivo deste artigo é verificar se as empresas de mercados economicamente regulados são desestimuladas a investir em pesquisa e desenvolvimento (P&D). A análise de dados de painel foi realizada em uma amostra de 55 empresas listadas na Bolsa Brasileira (B3), que publicaram informações sobre os montantes alocados às atividades de P&D. O período amostral compreende os anos de 2009 a 2014. Os resultados mostram que a regulação não atingiu significância estatística em relação ao nível de despesa em P&D. Contudo, confirmamos os efeitos de determinadas características das empresas, tais como tamanho e desempenho, em atividades de P&D. Esses resultados podem contribuir para a formulação de políticas públicas voltadas ao desenvolvimento econômico.

Palavras-chave: regulação, inovação, pesquisa e desenvolvimento, Bolsa Brasileira (B3).

Introduction

Historically, economic regulation has been justified by the State's need to preserve and secure the interests of society. In this sense, the regulation is considered imperative to protect and benefit the public, due to the existence of market failures (Pinheiro, 2015). Therefore, regulation is seen by public interest theory as a social claim that has been mitigating the suffering of the people against the abuse of modern organizations and acting as a defense of the general interest mechanism (Lima, 2005).

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However, based on empirical and critical studies, which have argued that regulation is often responsible for the benefit of regulated organizations rather than society, Stigler (1971) proposed the basis of the Theory of Economic Regulation (TER). For the author, the main purpose of TER is to explain and understand the benefits of regulation, how they occur and what their effects are. In addition, it justifies the existence of natural monopolies and oligopolies, as they allow the use of economies of scale for higher performance and lower costs (Stigler, 1971).

Thus, the infrastructure sectors such as electricity, telecommunication, transport, among others, are presented as natural oligopolies under the aegis of production efficiency. According to Levy and Spiller (1993), with the passage of time, efficient management practices may be discouraged in natural monopoly or oligopoly, due to the absence (or low) competition. For these authors, with the purpose of rescuing the incentives for good management practices and supporting the efficient production that emerges a regulatory framework. In the designing of Pires and Piccinini (1999), the regulation would also have the role of encouraging innovation.

In Brazil, R&D investment in the electricity sector, for example, is an obligation defined by Law No. 9.991, of 2000 (Brasil, 2000), as amended by Law No. 10.848 in 2004 (Brasil, 2004), and Law No. 11.465 in 2007 (Brasil, 2007), which provide for participation in R&D and energy efficiency by concessionaires, vested investors and licensees in the electricity sector - and is regulated by the corresponding decrees (Ziviani and Ferreira, 2016). Since then, this sector has applied hundreds yearly of millions of Reais in R&D.

From this point of view, the major regulatory challenge is the issue of producer profitability, concomitant with consumer welfare, translated into quality goods and services at reasonable prices (Levy and Spiller, 1993). Such efforts must, however, be aligned with the innovation activities already taking place in the regulated sectors.

According to Freeman and Soete (2014, p. 26), who are based on Schumpeterian thinking, when we think of innovation we must distinguish between it and invention. Although an invention is an idea, model, or abstract structure for a new or improved device, product, process, or system, it is not responsible for technological innovation. However, innovation is only complete in an economic way when the first commercial transaction involving the new product, process or system occurs.

Innovation is also, in Schumpeter's (1982) view, the driving force of entrepreneurial activity and, without the application of innovation by entrepreneurial activity, there would be no economic development. This argument holds true for the changes faced by industry in the twentieth century, such as vertical integration, and product differentiation and diversification. Innovation, therefore, is shown as a business competitiveness strategy.

Porter and Van der Linde (1995) developing the idea of environment-competitiveness argue that such "innovation offsets" can not only lower

the net cost of meeting environmental regulations but can even lead to absolute advantages over firms in foreign countries not subject to similar regulations. According to their idea, firms can benefit from properly crafted environmental regulations that are more stringent (or are imposed earlier) than those faced by their competitors in other countries. By stimulating innovation, strict environmental regulations can enhance competitiveness (Porter and Van der Linde, 1995, p. 101).

Some agree also that monopolistic structures tend to be more innovative than perfect competition ones, because to ensure their market position monopolistic companies need to innovate (Dosi, 2006). In his view, successful innovation would lead to extraordinary profits and difficult imitation.

On the other hand, the Schumpeterian theory also recommends that stimulating innovation is not present in monopoly or natural oligopoly, as companies belonging to these structures are the only producers of goods or services and therefore incur high irrecoverable costs. Moreover, these firms submit to government regulatory action without a competitive environment, which may inhibit investments in innovative activities.

Similarly, Rothwell (1981) places the regulation as an element of uncertainty concerning the operations of innovative entrepreneurs. Sometimes this involves rapid or obscure changes in regulatory standards and expenditures generated to cover the costs of compliance with regulation. The solution to this problem would be to reduce the tendency to take risks (Manners and Mason, 1979), which inevitably would lead to a decrease in spending on R&D, which is considered one of innovation inputs.

Given this context, we note that economic regulation, although active in ensuring goods and services that satisfy the society may end up discouraging investment in innovation. In this context, this article proposes the following question: Does market regulation affects the level of resources allocated to R&D?

To answer the proposed question, we define the following specific objectives: (a) identify the companies that make up the sample; (b) gather the economic and financial information of companies, and (c) verify the effects of regulation on the level of spending on R&D based on the application of an econometric model.

Research on the effects of regulation on innovation has indicated that a more rigorous economic regulation tends to hinder innovative activities (Pelkmans and Renda, 2014). However, according to Sav (1977), different cases were analyzed by dividing the businesses between regulated and unregulated. He found that a stricter regulation would reduce the R&D activities of regulated firms compared to those inserted in unregulated environments, ceteris paribus. In addition, Rothwell (1981) warns that firms submitted to regulation innovate less, making room for the supplier firms of goods and services to innovate more. This positive effect of innovation on unregulated sectors was also found in Ledezma (2009). Finally, Stewart (2010) emphasizes that the regulation

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may affect positively or negatively on R&D activities, varying according to the specific cases.

This paper focuses on the effects of regulation on R&D investment and is justified by the need to effectively subsidize policies that stimulate economic development. It takes into account the application of intellectual property rights and incentives to economic agents who innovate (Dosi, 2006). At the same time, it should be noted that research on regulation and its relationship with innovation still deserves attention on the national scene. Therefore, this article may contribute to the literature in the field, mainly by focusing a subject not well explored.

In order to respond to the proposed research problem and bring theoretical and practical contributions, this article is divided into five sections: the introduction, theoretical framework, adopted methodological procedures, discussion of the results, and reflection on the proposed objective as well as suggestions for future research.

Literature review

This literature review presents the topic of economic regulation in Brazil and explores innovation.

Economic regulation in Brazil

Economic regulation can be understood as a state action limiting the freedom of economic agents to carry out their activities and requiring them to contribute

to the state function of promoting social welfare (Stigler, 1971). According to Fiani (1998), this limitation is materialized by means of price control (tariffs), the quantity and quality of products, and service and investment goals.

In this sense, Scherer and Ross (1990) stated that regulation is directed primarily to the public utilities sector. It is justified mainly by two concepts: the first is the idea that the size of the company is so large in comparison to its market that the competition fails as a price, quantity, and quality disciplinarian. The second refers to the fact that even if the market is functioning properly, the political power holders may, for some reason, be dissatisfied with the results achieved by certain sectors of industry.

In Brazil, economic regulation can be analyzed from two distinct periods: the 1970s and the 1990s. In the 1970s, the development policy focused on state-owned enterprises and investment programs in the public sector, mainly in strategic fields such as oil and telecommunications (Matias-Pereira, 2004). Therefore, the regulatory action of the State was based on the protection of domestic industry. Unlike in the 1970s, the 1990s were characterized by economic liberalization initiated by President Fernando Collor de Melo, through programs such as industrial policy, foreign trade (ECIP), and the

National Privatization Program (PND) (Guimarães, 1996). Thus, regulatory policy turned to the defense of competition.

The New Public Management (NPM) was introduced in the public scenario of Brazil as an advance towards democratization, social participation, and state management, representing social innovation (Beinare and McCarthy, 2011). Campos and Camacho (2014) revealed that the Brazilian oil sector during the 90s underwent a significant change in function, relaxing the previous state monopoly and allowing the entry of private and state companies for the development of the entire oil production process. Their results showed that the different market structures present in the oil industry led to certain inefficiencies, resulting in social costs and, consequently, a loss of well-being for consumers.

This transformation of the Brazilian economy originated in the Federal Constitution of 1988, Art. 170, which resulted in a free market economy authoritative the value of human labor and free enterprise (Brasil, 1988). Subsequently, the enactment of Law No. 8.884 (Brasil, 1994) contributed to the consolidation of the state as a regulator. This legal provision, responsible for the repeal of Law No. 4.137 (Brasil, 1962), dealt with the prevention and repression of violations of the economic order and lifted the Administrative Council for Economic Defense (CADE) to federal agency status, giving it greater managerial autonomy. Currently in force is Law No. 12.529 (Brasil, 2011), which established a real structure antitrust: the Brazilian System of Competition Defense (SBDC).

The main idea of this change was an extension of the public sector involving change in social values at the institutional level, such as the citizenship and social inclusion. This involved the integration of new actors in decision making and implementation of public actions at the organizational level (Klering and Andrade, 2006).

However, one should remember that the application of this legislation was only intended for antitrust advice and to give regulatory agencies the function of evaluating and setting tariffs on the quantity and quality of goods or services (Teixeira, 2011). With this reasoning, Martins (2003) highlighted the operational difficulties faced by government agencies in exercising essential regulatory activities, such as regulation and supervision, which would involve the need to obtain autonomy and differentiated flexibility. Thus, regulatory agencies were created.

The adoption of the regulatory model, according to Pó and Abrucio (2006), took place during the first administration of Fernando Henrique Cardoso and was divided into three stages. The first, from 1996 to 1997, involved the creation of regulatory agencies relating to the privatization and monopoly break of the infrastructure sector, namely: the National Electric Energy Agency (ANEEL), the National Agency Telecommunications (ANATEL), and the National Petroleum Agency (ANP).

Between 1999 and 2000, which constituted the second stage, the Brazilian federal government focused on the efficiency and modernization of the state, especially regarding the social interests

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of citizens. In this context, the National Health Surveillance Agency (ANVISA) and the National Health Agency (ANS) were instituted.

In the final stage, from 2001 to 2002, the National Agency for Land Transport (ANTT), the National Agency of Waterway Transportation (ANTAQ), the National Water Agency (ANA), and the National Cinema Agency (ANCINE) were created. In 2005, under the governance of President Luiz Inácio Lula da Silva, the Brazilian National Civil Aviation Agency (ANAC) was created by Law No. 11.182 (Brasil, 2005).

Innovation and economic regulation governmen

Economic development requires change and leaving behind the status quo. According to Schumpeter (1982), this change requires innovation, which is achieved through the introduction of a new product in the market, origination of new productive combinations, and/or changes in production functions. Thus, we can learn that the act of innovation involves a complex process, and the creation of new products and/or technology is only one part of it. Similarly, Muniz and Plonski (2000) claimed that innovation is a social process in which the diffusion, imitation, improvement, and discovery of marketing are integral elements.

Dosi (2006) explained the capacity for innovation and market structures and established the following pattern. (1) Market structures and firm sizes are endogenous variables, which depend on the nature and rate of technical progress. (2) Major technological opportunities and high levels of private appropriability generate large companies and cause high levels of concentration. (3) A company is likely large because it has been successful in its cumulative innovation activity. If there are many technological opportunities, its competitive advantage over the other businesses will be considerable, resulting in greater participation and higher levels of market concentration. (4) Concentration and market power, as well as technological developments, influence the current incentives for innovation, as they affect appropriability of innovations. This, in turn, is directly related to participation in the company's market and the concentration of the industrial sector, as well as oligopolistic rivalry standards (Dosi, 2006, p. 142).

Innovation is a risky activity for organizations, and regulation can be an element that enhances this problem. According to Rothwell (1981), regulation implies uncertainty derived from various sources, such as inadequate changes in regulatory standards and inconsistencies between national and international standards. Thus, one of the consequences of regulation is the reduction of risks and uncertainties through the reduction of R&D activities (Manners and Mason, 1979).

The issue of cash flow of the companies belonging to the regulated sectors is noteworthy. The delay between the rate increase request and the authorization granted by the regulator can generate financial inconveniences for industries. Therefore, the reduction in spending on R&D would be a natural result (Rothwell, 1981).

The information regarding the financial sacrifices made for R&D is even one of the ways to measure innovation, as it represents a company's input. This measure has been seen as an indicator of technological progressiveness for companies, industries, or nations (Cohen and Kepler, 1996). Jones and Williams (2000), in a broader view, claimed that spending on R&D is crucial to the productivity and well-being of the company and consumers. The fact is that the level of spending on R&D has been used worldwide to evaluate the technological level of the agents and, consequently, their innovation activities.

The study by Sav (1977) demonstrated that U.S. power companies invested less in R&D when inserted into a strict regulatory environment. The rationale would be that regulated firm managers have less incentive to innovate because the wealth generated by the innovation would not maximize its usefulness. Regarding this issue, Sterlacchini (2012) more recently discovered some interesting results about the processes of liberalization and privatization. According to his finding, the last two decades have witnessed a staggering decline of R&D investment in the fields of energy and electricity. A closer inspection of recent data concerned with ten major electric companies in the world showed that the drop in research expenditures was particularly strong among private or newly-privatized companies. In contrast, those that remained under public control did not remarkably reduce their R&D efforts.

Bassanini and Ernst (2002) investigated the effects of labor market regulation on innovation in 18 countries in the Organization for Economic Cooperation and Development (OECD). They found positive evidence of association between the flexibility of the labor market and the level of spending on R&D in low-tech industries and countries whose industries are not coordinated. The reverse was found, however, in countries where the market is more regulated because the association between variables was negative.

The research by Prieger (2002) examined the effects of regulation on innovation and services in the telecommunications sector in the U.S. The econometric model tested showed evidence that, in general, companies added 62% more services in the market if there were no regulations in their industry. Therefore, regulation exerted negative impacts on industry innovation services.

Ledezma (2009) studied 14 OECD countries from 1987-2003 and found a positive effect between market regulation and R&D of high-tech industries. This result confirmed the assumption by Rothwell (1981), who proposed that the regulated sector supports compliance to regulatory costs, which results in less investing in R&D, whereas the supplier industry reaps the benefits of the market and innovates through products and/or processes.

Eger and Mählich (2014) studied the relationship between regulation and the level of expenditure on R&D; however, they focused on the pharmaceutical industry. Unlike other surveys, they used financial variables such as cash flow and financial leverage in the model. As a

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result, they concluded that regulation deteriorates incentives for the pharmaceutical industry to invest in R&D.

That being said, there are reasons to believe that economic market regulation also constitutes an important element of investment in R&D by companies established in Brazil. Based on the liberalization process and regulation agencies that were created, we proposed to test the hypothesis that economically-regulated companies tend to spend fewer resources on R&D activities (Sav, 1977; Prieger, 2002; Jamasb and Pollitt, 2008; Eger and Mählich, 2014).

Methodology

This study is characterized as descriptive in relation to its objectives; pure with respect to the nature of their problem; quantitative regarding the problem and laboratory approach to its environment. As for technical procedures, it is bibliographical and documentary.

The population covers publicly traded companies listed on the B3. Of this population, the sample was extracted from the non-probabilistic type, which brought together 55 companies. Came to this number from query to the database Bloomberg ® combined with examination of the Standardized Financial Statements (SFS) filed with the Securities and Exchange Commission (CVM). Thus, the sample included companies that have reported data for the expenditure on R&D from 2009 to 2014.

Overall, the financial data were collected on Bloomberg® base and the DFPs companies. Data on the age of the firms have been achieved through consultation with the National Register of Legal Entities (CNPJ) available on the IRS Web site of Brazil. Already the numbers of CNPJs companies were obtained through the homepage of the B3.

The hypothesis examined in this study was formulated based on the economic theory of regulation and on the results of previous research. Thus, one has :

Economically regulated companies tend to spend fewer resources on R&D activities.

In order to test this hypothesis, we used multiple linear regression with panel data, since the combination of time series with cross-sections was appropriate to the research problem. Thus, the data on 330 observations obtained were tabulated in Excel ® software and then imported into Stata ® statistical software, version 12, which were duly organized in balanced and treated panels.

The econometric model tested is shown in Equation 1:

$$SpendR\&D = \beta_0 + \beta_1 Size_{it} + \beta_2 Perfor_{it} + \beta_3 Lev_{it} + \beta_4 Age_{it} + \beta_5 Reg_{it} + \beta_6 ES_{it} + \beta_7 ITS_{it} + u_{it} + \varepsilon_{it}$$

where SpendR&D is spending on R&D, $Size_{it}$ is size of companies, $Perfor_{it}$ is performance of companies, Lev_{it} is level of financial leverage of companies, Age_{it} is formal existence of time the company, Reg_{it} is

economic regulation expressed by a Regulator Agency, ESit is electric sector companies', ITSit is information technology sector companies'.

The dependent variable is intended to express the level of spending on research and development in companies and is calculated using the ratio of expenditure on R&D and total assets. This measure is recurrent in research aimed at R&D activities of companies (see Abdullah et al., 2002; Tribo et al., 2007; Di Vito et al., 2010).

The variable Size is intended to express the size of the companies, using up to this, the data relating to total assets. It is expected that this variable presents a negative association with the level of spending on R&D. We follow Levy and Spiller (1993) who consider that, as the time passes, efficient management practices may be discouraged in large companies as well in concentrated market.

The ratio of net income and total assets aims to demonstrate the performance of companies, which is represented by Perform variable. Pending a positive relationship between it and the SpendR&D variable, as companies with good performance are favorable conditions to invest in R&D.

Another independent variable is Lev, which sets the level of financial leverage of companies. This variable was constructed based on the ratio of the required subject and the net worth of companies. It is expected that its coefficient is negative, since the lesser degree of leverage allows for free resources for application which, in turn, can be used for R&D activities.

Also included in the model, the variable Age intends to capture the effect of the formal existence of time the company on the level of spending on R&D. It is believed that ancient firms in the market tend to invest less in research and development, which is why a negative coefficient is expected (Czarnitzki and Kraft, 2009).

The economic regulation expressed through the dummy Reg variable has the following values: 1 to member companies of economically regulated industries by the government and 0 for others. This variable was based in the fact that there were created or not specific Regulation Agency for the sector, as we have presented in the first section of Literature review. A negative coefficient is expected for this variable.

The variable ES intends to control the effect that electric companies in the sector may cause the results. This dummy has value 1 to companies operating in the electricity sector and 0 for others. The concern with this sector is justified by the legal requirement that electric companies have to invest a portion of its net operating revenue in R&D activities (Law No. 9.991/2000).

Finally, the ITS variable attempts to control the impact of the information technology (IT) sector may cause, for this field of activity, by nature, tend to invest heavily in R&D. In order to be a categorical variable, it shows the value 1 to companies belonging to the IT industry and 0 for others.

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Discussion

The sample, as already mentioned, was composed of 55 companies listed on the B3, distributed in economic sectors as shown in Figure 1.
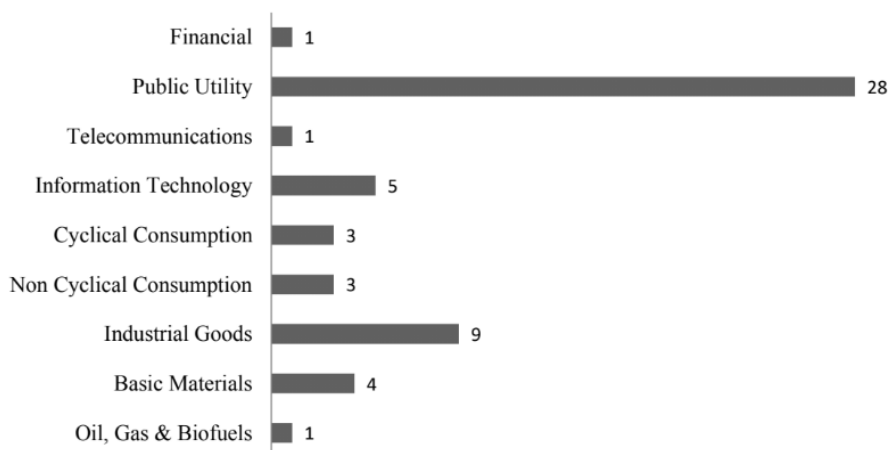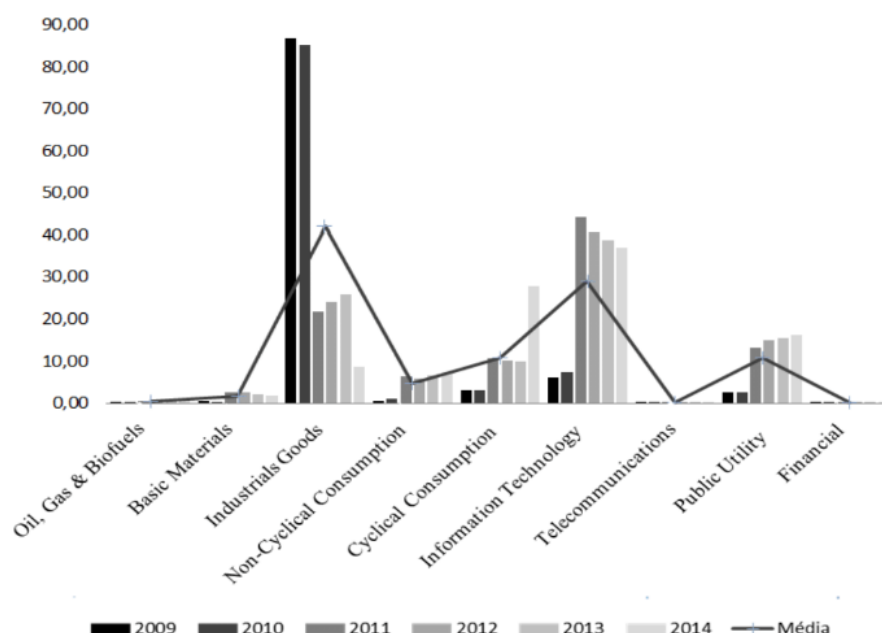

Figure 1.
Number of sample enterprises by economic sector.

Among all analyzed companies, those operating in the utility sector predominated, accounting for 50.91% of the total. Of these, 27, or approximately 49%, are in the electricity subsector. The large share of this subsector in the sample is due to the Law No. 9.991 passed in July 24, 2000. Article 1 of that statute requires concessionaires and licensees of public electricity services to implement annually the minimum amount of 0.75% of their net operating revenue in R&D activities (Law no. 9.991/2000). Therefore, companies in this subsector need to report this information on their financial statements.

The sector of industrial goods, with nine companies, represents 16.36% of the total. This sector is responsible for the production of goods for other industrial sectors and, therefore, plays a prominent role in the dissemination of technology, which justifies its relevance in the sample.

The third most representative sector in the sample was Information Technology, which notoriously has as main feature the creation of solutions and systems for individuals and organizations. Thus, this sector has the need to allocate resources for research and development of new products.

Figure 2 shows the level of spending on R&D as a percentage, as well as their average per economic sector.

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Figure 2.

Spend on R&D by economic sector, from 2009 to 2014.

For the years 2009 and 2010, it can be observed that the industrial goods and information technology sectors spent the most on R&D resources, with 86.83% and 6.21% of shares in 2009 and 85.20% and 7.40% in 2010, respectively. From 2011 onwards, the technology sector took the lead in R&D spending, with 44.18%, 40.85%, 38.83%, and 36.85% during this period, while the industrial goods sector ranked second by 2013, with 21.90%, 24.17%, and 25.78%. In 2014, the consumer discretionary sector took the second position with 27.74%.

Regarding the level of spending on R&D, it can be observed that the public utility sector, which had the largest number of companies, was only fourth in spending by the year 2011, jumping to third in 2012. Their average level of spending on R&D was 10.86%, which places it as the third company with the most investments in R&D.

The companies showed average total assets of R$24.8 billion, with a minimum value of R$47 million and a maximum of R$793 billion. The minimum value corresponded to an electric company in the year 2014, and the maximum value referred to the only firm in the oil, gas, and biofuels sector, also in 2014. This variation shows the large difference between the sizes of the companies studied, but it can also be explained by the sectors involved, according to Thomson Reuters' 2015 State of Innovation in the world report (Thomson Reuters, 2015). While our study used expenses in financial reports as a measure of R&D investments, the Thomson Reuters' (2015) report examined patent-filing as a concrete measurement of innovation. This report showed that of more than 1.2 million patents filed across 12 industries in 2014, 30% were in the information technology industry, a far greater chunk than any other industry. Another 13% were related to telecommunications, 12% were automotive, and oil and gas had only 2%.

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The Lev variable reached its peak in 2013 with a company in the industrial goods sector. In this case, its total liabilities represented 53.22% of its shareholder's equity. The "within" variation was higher than the "between" variation, which means that this index had a greater change over time.

The Perform variable, responsible for estimating the performance of companies, obtained greater variability over time for each individual than the variation between the companies themselves. Its maximum value, 0.96, was obtained by an electric corporation in 2009 and is considered a great mark. On the other hand, its minimum value, -1.90, indicates a poor result, and this value was also earned by an electric firm, this time in 2012. In fact, these -1.90 result was caused by a net loss of R$797 million. Although the average performance was .042, we cannot confirm that companies had poor performance on average because our sample is composed of very different sectors and is distributed over 6 years.

With respect to the age of the firms, the oldest company is 62 years old. This firm belongs to the public utility sector, specifically the electricity subsector. In turn, the youngest enterprises were legally formalized 3 years ago. On average, the enterprises are about 30 years old.

Regarding the multivariate analysis of the data, the first step was to verify the normal distribution of the error term. Therefore, we analyzed the indicative of skewness and kurtosis of all the variables, and the results showed that the data did not present a normal distribution. Therefore, we proceeded with the transformation of the variables by applying a natural logarithm. After this change, the problem of non-normality was fixed. However, the consequence of this transformation was that the coefficients of the variables began to express the elasticities of the dependent variable, SpendR&D. The econometric model is represented by Equation 2:

$$lnSpendR\&D_{it} = \beta_0 + \beta_1 lnSize_{it} + \beta_2 lnPerform_{it} + \beta_3 lnLev_{it} + \beta_4 lnAge_{it} + \beta_5 Reg_{it} + \beta_6 ES_{it} + \beta_7 ITS_{it} + u_{it} + \varepsilon_{it}$$

Then, in order to make sure that the model did not present strong multicollinearity problem, we consulted the correlation matrix between the variables as showed in Table 2.

Table 2.

Correlation matrix between variables.

Variables	lnSpendR&D	lnSize	lnLev	lnPerform	lnAge	Reg	ES	ITS
lnSpendR&D	1.0000							
lnSize	-0.4605	1.0000						
lnLev	-0.1455	0.2211	1.0000					
lnPerform	0.1662	-0.2287	-0.1264	1.0000				
lnAge	0.0403	0.2293	0.0269	-0.0772	1.0000			
Reg	-0.4160	0.1787	0.0986	0.1298	-0.3401	1.0000		
ES	-0.4253	0.0496	0.0760	0.1492	-0.2464	0.7790	1.0000	
ITS	0.4026	-0.2528	-0.2882	-0.0590	0.0061	-0.3538	-0.2756	1.0000

Table 2 demonstrates that there was no strong correlation between the independent variables. Even the highest coefficient of correlation, perceived between the variables lnLev and ITS, indicate a weak correlation, resulting in the negative value of 0.2882.

Once we examined the basic assumptions of the regression model, we run the multiple regression analysis with panel data (PDA). Then, we performed the Hausman and Breusch-Pagan tests to identify the most suitable model. The results pointed to the random effects model. Table 3 shows the output obtained using this model.

Table 3.
Estimation of panel regression model with random effects.

lnSpendR&D	Coefficient	Standard error	z	P>z	[95% Conf. Interval]	
lnSize	-.2718602	.0797821	-3.41	0.001	-.4282302	-.1154902
lnLev	-.2080209	.11642	-1.79	0.074	-.4361998	.0201581
lnPerform	.1456655	.0378674	3.85	0.000	.0714469	.2198842
lnAge	.2652244	.1714171	1.55	0.122	-.0707469	.6011957
Reg	.0614946	.5323739	0.12	0.908	-.9819391	1.104.928
ES	-1.011.727	.4930666	-2.05	0.040	-197.812	-.0453341
ITS	1.154.768	.609734	1.89	0.058	-.0402882	2.349.825
_const	.6528169	1.669.859	0.39	0.696	-2.620.047	3.925.681

First, the discussion will be focused on the biggest aim of this paper: the relationship between economic regulation and the spending on R&D by the firms. Theref

ship between economic regulation and the spending on R&D by the firms. Therefore, with the use of the dummy variable Reg, we found that market regulation did not significantly influence the level of spending on R&D (p = 0.908), which means that there is no evidence for accepting . In addition, its coefficient was positive, contrary to what was expected. Therefore, it is not possible to claim that economic regulation, in the context of this research, was a factor that discouraged investments in the innovation input R&D. In some of the sectors, this result may be explained by strict environmental regulations, which can enhance competitiveness and encourage investments, stimulating innovation (Porter and Van der Linde, 1995, p. 101).

This result is contrary to the assumption by Rothwell (1981), who stated that the regulated sector supports compliance to regulatory costs, resulting in less investment in R&D. However, after discovering these results, we investigated the Innovation Survey (IBGE, 2016) in Brazil. It is a research survey conducted every 3 years, covering the sectors of industry, services, electricity, and gas. This survey gathers information regarding the construction of national indicators on the activities of innovation undertaken by Brazilian companies.

The latest available research data from IBGE (2016) is from the year 2014, and it shows an interesting result: 74.83% of organizations that received investments by government support programs related that

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innovation was possible due to financing received for the purchase of machinery and equipment needed to innovate. This can lead to new research that compares the reasons for innovation by country. Also, it is a result that is congruent with Dosi's (2006) explanation of how Japan was able to improve its technological and automotive sector thanks to governmental support.

Concerning to the effect of a company's size on the level of spending on R&D, we can see in Table 3 that the variable lnSize was statistically significant (p < .01), with a negative coefficient. Therefore, we can infer that this relationship is inversely proportional to the level of expenditure on R&D: the larger the size of the company, the lower its tendency to incur expenditures on R&D. This result confirms the postulation by Schumpeter (1982).

The variable lnLev, referring to the level of financial leverage, had a negative coefficient, the same as that achieved by Eger and Mählich (2014). However, with a p value of 0.074, we could not confirm the statistical significance at a 95% confidence level. Therefore, it is not possible to state that lnLev exerts effects on the level of spending on R&D.

The variable lnPerform showed a positive coefficient, as expected, and this was also statistically significant (p < .01). Consequently, there is evidence to suggest that the better the performance of the organization, the more likely it to invest in R&D.

Regarding the variable lnAge, this was not statistically significant, given its p value of 0.122. Thus, the age of a company does not have any significant impact on the level of spending on R&D.

Concerning the ES control variable, the dummy representative of the electricity sector, it had an inverse relation with the level of expenditure on R&D. Thus, it is understood that the presence of legal enforcement in this sector to apply part of its revenue in R&D does not cause electric companies to invest more in R&D than they would have otherwise.

The TIS control variable, likewise, was statistically insignificant (p > .05). Thus, it is not possible to say that companies belonging to the IT sector, although mainly focused on creating systems and solutions, are more likely to invest in R&D activities.

One point that cannot be overlooked, however, is the question of examination of other basic assumptions of regression, which could only be analyzed after the model was tested. This time, problems regarding the autocorrelation and heteroscedasticity were checked. For this, we used the Wooldridge test for autocorrelation, which showed the presence of the anomaly. Therefore, we opted for the robust estimate of regression, which generated the results presented in Table 4.

Thus, we opted for a robust regression estimation, which generated the results presented in Table 4.

Table 4.

Estimation of panel regression model with random effects (Robust).

lnINT	Coefficient	Robust Coefficient Standard Error	z	P>z	[95% Conf. Interval]	
lnSize	-.2718602	.1106308	-2.46	0.014	-.4886926	-.0550278
lnLev	-.2080209	.2362168	-0.88	0.379	-.6709972	.2549555
lnPerform	.1456655	.0456617	3.19	0.001	.0561702	.2351609
lnAge	.2652244	.2282488	1.16	0.245	-.182135	.7125838
Reg	.0614946	.6533943	0.09	0.925	-1.219.135	1.342.124
ES	-1.011.727	.5430962	-1.86	0.062	-2.076.176	.0527221
ITS	1.154.768	.6241562	1.85	0.064	-.0685552	2.378.092
cons	1.669.859	2.242.853	0.29	0.771	-3.743.095	5.048.728

Regarding the permanency of statistical significance, the results achieved by the robust standard error estimation coincided with the OLS estimation. The *lnSize* variable had a small change in its value, from 0.001 to 0.014, which did not affect the previous analysis.

Likewise, the *lnPerform* variable changed from 0.000 to 0.001. Thus, performance presented a directly proportional relationship to the level of spending on R&D.

However, the *ES* control variable failed to achieve statistical significance at a level of 5%, as its new p-value was 0.062. Hence, the results offered by Table 4 are more suitable due to its robust estimation and, consequently, we infer that the electrical subsector has no effect on the level of spending on R&D.

Conclusion

Innovation is a broad field of scientific research, so many studies have been conducted in the field, dedicated mainly to the analysis of its determinants. Similarly, research on the regulation of economic sectors is frequent. The relationship between innovation, measured by the level of R&D spending and market regulation, is becoming more popular, albeit latently on the international scene. Therefore, financial and economic variables such as total assets, performance, leverage, export and growth rates have been used to explain R&D expenditures.

The Theory of Economic Regulation (TER) holds that market regulations impose high costs on businesses, forcing them to allocate resources in legally established activities at the expense of those related to innovation. Thus, a negative effect of regulation on R&D is expected.

In this sense, this article focused on the analysis of the relationship between economically regulated industries and the level of spending on R&D. It was based on a sample of companies listed on B3 for the period from 2009 to 2014, and it included companies in the Standardized Financial Demonstrations, which contains information on R&D expenditures.

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The descriptive analysis of the data allowed us to observe that, on average, the industrial goods sector allocated more resources to R&D activities, followed by information technology and utilities. The oil, gas, fuel, and telecommunications sector, with one company each, did not reach such significant expenditures on R&D.

Complementarily, empirical evidence was found determining that the size of the company and its performance have an effect on the intensity of R&D. For the size variable, the effect was negative, whereas for performance, the relation was positive.

When multiple regression analysis of data panels was performed, the hypothesis of the inverse relationship between regulation and the level of expenditure on R&D was not confirmed, as the dummy Reg did not achieve statistical significance. This result suggests that, contrary to the findings by Rothwell (1981), strict regulation has no influence on investments in R&D.

In addition, we found empirical evidence that the size of the company and its performance have no effect on the level of spending on R&D. For *lnSize* (size variable measured by total assets of the company), the effect was found to be negative, while for *lnPerform*, the relationship was positive.

The *ESS* an*d TIS* control variables showed no statistically significant relationship with the level of spending on R&D. Thus, empirical evidence was not found in the proposed model to support the belief that belonging to specific industries is a determinant factor for the level of spending on R&D.

Therefore, this research contributes to the theoretical aspect by enriching Brazilian literature with regards to investments in R&D. In a practical sense, it increases understanding of the relationship between economic regulation and innovation and enables advances in the formulation of economic policies. By comparing IBGE (2016) with our results, we can infer that it is not the regulation itself that determinates innovation investments, but rather the type of governmental policies regarding innovation. We believe that the government must encourage and regulate concomitant innovation, so we suggest that economic policy must take into account the culture of Brazilian organizations by sector to provide economic development opportunities and not poorly-planned tax incentives, economic subsidies, or isolated incentives.

Finally, it is imperative to point out that the findings of this article should not be generalized. We faced limitations in respect to the sample size, because a small number of companies disclosed information on investments in R&D during the analyzed period. Moreover, the tested model used as the dependent variable was a particular measure of input in innovation. Some other metrics could have been applied.

For future research work, we recommend studying output measures of R&D, such as the number of patent requests, and expanding this study with the use of other explanatory variables. It is also noteworthy that the measure of regulation can be improved by means of proper indicators.

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