The informatics technology and innovation in the service production

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**Abstract**

This paper aims to analyze how informatics technology affects the innovation of the service production process. As its main characteristic, the production of services is very intensive in human capital to produce outputs, and since the development of informatics technology affects certain tasks used to produce output, it will bring innovation to the procedures in the production of services. Thus, evaluating the use of informatics (e.g., computers) in the service sector represents innovation in services and, more precisely, in their production process. Based on a Brazilian database with detailed information on sectors, occupations and the use of computer technology and using panel regressions with fixed effects, we show that the use of computers changed the execution of certain tasks, increasing the demand for a specific type of non-routine tasks. The use of informatics technology in the service sector displayed a shift toward non-routine analytical activities. Regarding the impact of informatics technology on the service sector relative to non-service sectors, while informatics technology has been used intensely to automate manufacturing, displacing workers from routine tasks, the same cannot be said for the service sector. The analysis of the use of informatics technology in different segments of the service sector shows that informatics technology has a heterogeneous effect on the production process that varies according to how sectors use technology to complement or substitute labor tasks.

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1. Introduction

The strong interdependence of economies in a globalizing world causes companies to face an increasingly risky and competitive environment. One possible solution to overcome such a hostile business environment is the use of informatics technology to innovate in products, services and processes (Sirilli and Evangelista, 1998).

The success of firms in the service sector represents an important contribution to the country, since it is a significant source of employment. In recent decades there has been strong evidence of this sector's development and its increasing relevance to the economy, mainly due to innovation, competition, employment and growth (see De Jong et al., 2003; Hauknes, 1998; Howells and Tether, 2004; Tether, 2005).

Considering the relevance of this sector and the impact of innovation on it (see Miles, 1993), this paper focuses on innovation in services regarding their production process. The production process is a set of tasks carried out by the service supplier (see Agya Valley and Singh Sekhon, 2014; Barras, 1986), and innovation in the service production process is defined as a change in the set of tasks required to perform the production process (Djellal and Gallouj, 2007). Therefore, this paper aims to answer the following question: is the set of tasks performed in the service sector affected by informatics technology?

From a policy perspective, it is crucial to understand how the labor market is affected by a change in informatics technology and which kinds of tasks are more demanded. From the government's view, strategies that subsidize and invest in the labor market can be designed to facilitate the flow of workers between jobs that involve different types of tasks. On the other hand, from companies' view, strategies of training and investment in workers can be designed to maximize the productivity gains from the dissemination of this technology. Bloom et al. (2012) evidence higher productivity gains from technology when firms are more able to manage people and their skills.

This study approaches a subject that is still insipid in the service literature, dealing with the influence of informatics technology on the production of services. As stated by Vence and Trigo (2009), the discussion of innovation in services focuses on the development of new types of services. Debates on innovation of the production process, a factor that tends to improve the existing service, reduce the costs and/or increase the aggregated value, are still rare. Accordingly, it is necessary to consider the influence of technology on production, allowing automation and better conditions in service output (Agya Valley and Singh Sekhon, 2014; Barras, 1986; Collier, 1998).
Thus, our goal is to determine whether informatics technology affects the service production process, resulting in innovation. As its main characteristic, the production of services is the sum of a set of tasks performed by workers to produce outputs (Djellal and Galloy, 2007; Carmona-Lavado et al., 2013), and the development of informatics technology affects certain tasks executed to produce outputs, which represents innovation in the service production process (henceforth ISPP). Thus, the use of informatics technology in the service sector is an innovation in services, more precisely in their production process (Agya Valley and Singh Sekhon, 2014).

As our specific goals, we focus on: (a) comparing the effects of informatics technology on the labor tasks carried out in the service sector with those performed in the manufacturing sector; and (b) identifying the segments of the service sector that are the most affected by informatics technology.

To answer our questions, we take advantage of the sudden end of an informatics technology barrier: the Informatics Law in Brazil. This law was enacted in 1984 to control the importation of computers, with the purpose of nurturing a homegrown computer industry. The policy proved unsuccessful, and the law was repealed in 1992, triggering a surge in the importation of informatics technology products, which rose by nearly 400% from 1992 to 1997 (Botelho et al., 1999).

Based on this episode, we estimate the impact of the use of informatics technology on the performance of each kind of task in the Brazilian service sector. Using panel regressions with fixed effects, we show that the use of informatics technology changed the production process in the service sector by increasing the use of a specific type of non-routine tasks. We also show that the effect is stronger for non-service sectors than for the service sector, since they substitute routine tasks for non-routine tasks that complement technology.

From the policy perspective, these results may orient government investment policies in technical education to ease the flow of workers between different types of jobs and different tasks. The lack of this policy is one of the reasons that contributed to the surge of the Rest Belt in the United States (see Akst, 2013). The development of automation technology in the 1960s had job-killing effects in areas intensive in routine manual tasks. Concerning the service sector itself, technology can create jobs instead of destroying them, since the use of technology increases innovation with tasks that complement technology, such as non-routine analytical tasks. Thus, from service sector companies’ perspective, informatics technology boosts workers’ productivity, mainly for those who perform non-routine analytical tasks. Therefore, investments in training focusing on this type of task tend to bring higher returns to the company.

The remainder of this paper is organized as follows: Section 2 discusses innovation in the service sector, innovation in service procedures and the potential impacts of new informatics technologies on the production process; Section 3 discusses the interaction between labor tasks and informatics technology in the service sector; Section 4 presents the database; Section 5 reports the empirical results; and Section 6 concludes.

2. Innovation in the service sector and ISPP

As stated by Miles (2001), research on services has been growing since the 1960s. Among the investigated topics, there has been special interest in the innovation theme. For several decades the service sector has grown faster on average than other sectors (see Segal-Horn, 2006; Sundbo, 2009) with regard to both the generation of new jobs and income. The service sector involves a huge number of different activities, with very different characteristics (Drach-Zahavy and Somech, 2013; Drejer, 2004; Groen et al., 2012; Hauknes, 1998; Hipp and Grupp, 2005; Miles, 2005; Savona and Steinmueller, 2013; Vries, 2006).

To boost innovation, the recent deregulation and globalization of markets and the internationalization of service firms have sharpened the competition among service companies (Elche and González, 2008). This has encouraged innovation in this sector, as firms try to increase their competitiveness in response to this new economic scenario. Environments like this require a constant search for innovation in service procedures, leading to lower costs and/or aggregating more value to consumers (Djellal and Galloy, 2008; Stevens and Dimitriadis, 2005).

As stated in the Oslo Manual (OECD, 2005), innovation in services is organized in a less formal way, tending to be less technological and more complementary to human capital, which is its main input. Sundbo and Galloy (1998, 2000) divide innovation in services into five different categories: product innovation (a new service or a new product of which sales imply a service); innovation in the process (a change in one or more procedures to produce or supply a service); organizational innovation (a new way to manage the organization); market innovation (changes in the market, such as the development of a new segment); and ad hoc innovation (the search for a solution to a specific problem presented by a client).

The analysis of innovation in the service field tends to be more difficult for two reasons: first, theories on innovation have been developed that focus on the manufacturing sector; and second, it is challenging to measure and find changes in the service sector due to its intrinsic characteristics (Galloy and Weinstein, 1997). To deal with this second problem, the literature generally evidences innovation indirectly, for example the use of technology in service production (see Djellal and Galloy, 2007).

According to the Oslo Manual (OECD, 2005:53), in the service sector, the distinction between product and process innovation is a relevant issue, since the two happen simultaneously. The manual states that:

(1) If the innovation involves new or significantly improved characteristics of the service offered to customers, it is product innovation;
(2) If the innovation involves new or significantly improved methods, equipment and/or skills used to perform the service, it is a process innovation;
(3) If the innovation involves significant improvements in both the characteristics of the service offered and in the methods, equipment and/or skills used to perform the service, it is both a product and a process innovation.

Barras’s (1986) model, called the “reversed product cycle,” defines innovation in services as beginning in most cases with changes in the set of tasks performed in producing services. The main goal of such innovation is to improve the current process’s efficiency. These initial marginal innovations are amplified and improved through time, ending in innovation in the product or the creation of a new type of service. The author asserts that innovation in production procedures can be summarized as changes in the set of tasks performed by workers. These kinds of innovations are less formal and more associated with new equipment and human resources.

The literature concludes that innovation in processes has a direct impact (more than the other types of innovation in services) on the realization of tasks by workers, affecting the distribution of jobs in different economic sectors, as stated by Djellal and Galloy (2007). Acemoglu and Autor (2010, 2012) present a theoretical model to explain how this phenomenon happens. They show that a change in technology produces a reallocation of workers’ skills to different
tasks. Workers migrate from tasks that are replaced by this technology to those that are not performed by informatics technology or those that complement its use. By increasing the intensive use of such technology, the task-replacing technological change complements each of the remaining tasks performed by workers. This event produces a change in the way in which services are rendered and therefore creates innovation in the service production process.

The natural result of ISPP is a change in the formal employment structure, since some types of jobs disappear and some are created (Planta, 2005). Evangelista and Savona (2003) show a reduction in routine tasks that demand basic skills from workers and an increase in more complex tasks that require higher skills, opening job opportunities for people who are capable of executing the new tasks.

This change in the distribution of human capital in service companies after innovation in processes is demonstrated by several authors (e.g., Corrocher et al., 2013; D’Este et al., 2014; Djellal and Gallouj, 2007; Drach-Zahavy and Somech, 2013; Fung, 2006; Greenan and Guellec, 2001; Piva and Vivarelli, 2005; Rubalcaba et al., 2012; Sillanpää, 2013). According to Djellal and Gallouj (2007), ISPP tends to reduce routine tasks and increase non-routine tasks, such as sales and consulting activities, with higher aggregate value and a demand for more skilled workers. These changes in the tasks performed by service suppliers have been affected by technological evolution, and such changes are defined as ISPP.

With the evolution of technology, its use in services is becoming more intensive, with relevant consequences for economic variables, such as productivity and employment (Dilaver, 2014; Licht and Moch, 1998). The use of technology demands more qualified labor — due to changes in the tasks performed — and both are used by service firms to improve the quality of services, reach new markets and/or reduce costs (Toivonen and Tuominen, 2009; Urraca-Ruiz, 2013).

Contrary to the findings of other authors that innovation creates job opportunities (Agya Valley and Singh Sekhon, 2014; Bogliacino et al., 2013; De Jong et al., 2003; Hauknes, 1998; Howells and Tether, 2004; Rusane et al., 2014; Sillanpää, 2013; Tether, 2005), Djellal and Gallouj (2007) argue that the use of informatics technology first has the objective of reducing costs by labor automation. Barras (1986) states that innovation in processes reduces job opportunities first and only creates new jobs in the long term, because the new tasks (non-routine tasks) created from the evolution of informatics demand more qualified human resources (Djellal and Gallouj, 2007).

3. The Brazilian market reserve policy

In the early 1970s, Brazil started its first initiative to protect the computer industry. During this period, the country was experiencing significant economic growth, and computer needs were mostly served through imports and by local subsidiaries of foreign companies.

In 1976 a computer policy was enforced by the Government. The policy intended to reserve the market for powerful computers (“mainframe” computers) for multinational corporations (such as IBM, Hewlett-Packard and others). On the other hand, a plan for developing local productive capabilities gave priority to the market for small computers and peripherals, presumably with technology that was easier to master. Together with this action, the Government controlled all purchases of data-processing equipment and software by public authorities (Pederson, 2005).

In 1984 the Informatics Law was enacted. For eight years it imposed a limit on access by foreign companies to the manufacture of small computers, extended the market reserve policy, including the requirements for the telecommunication sector as well as some components, and provided various support mechanisms for strictly nationally controlled companies. This strategy was a dismal failure in promoting the homegrown capability to match international developments in this sector. Consequently, local industrial users of computers and other microelectronics goods were unable to access the latest international innovations.

The market reserve policy ended in 1992 as part of the overall liberalization of the Brazilian economy, being replaced by a tax policy and financial incentives. As a consequence, most private Brazilian producers in the informatics sector went bankrupt, sold out to foreign competitors or left this market completely. The importation of information technology products rose by nearly 400% from 1992 to 1997. In the same period, the Brazilian information technology market grew by 16% a year on average (Tigre and Botelho, 1999).

The diffusion of information technology throughout the Brazilian economy was highly uneven, with large firms and advanced industrial sectors responding rapidly while smaller firms, peripheral regions and government entities remained marginal users.

In this paper we try to shed light on the effect of this abrupt opening of the computer technology market on the performance of routine and non-routine tasks.

4. Informatics technology and ISPP: routine and non-routine tasks

Informatics technology has made a major breakthrough in all economic sectors and nowadays is used for various purposes. However, it is still similar to the technology from previous decades, as machines are able to run quickly and accurately a set of tasks specified deterministically through a logical and unambiguous code, using a programming language (Autor et al., 2003). Due to advances in the capability of microprocessors and algorithms, complex calculations, such as those needed to optimize a system with many variables in operational research, which would have taken hours to process on mainframe computers some years ago, can now be performed in minutes on a personal computer, available at affordable prices to a wide variety of firms. Computers are widely used for tasks such as performing calculations or saving, retrieving and distributing information.

From this view of informatics technology, Autor et al. (2003) define work as a sequence of tasks to be performed and classify these tasks into five groups according to the capability to automate them: routine cognitive (RC), routine manual (RM), non-routine analytical (NA), non-routine interactive (NI) and non-routine manual activities (NM). According to this definition, routine tasks are those that can be performed by computers, namely repetitive tasks that can previously be specified unambiguously using a computer program. Some of these routine tasks need cognitive ability, for instance to perform the calculation of the amount of tax to be paid on an invoice. Current computer systems are able to calculate tax rates, record the accounting books and update the inventory, all embedded within a single operation. Thus, one sequence of routine tasks, performed years ago by several professionals, is currently performed automatically, faster and with reduced error risk by computers. On the other hand, another kind of routine task depends on the performance of manual skills. As an example, we can discuss the process of storing goods in the warehouse of a distribution company. Upon receiving an order, packages need to be moved to a specific location in the warehouse. Using the current technology, this process can be performed by a computerized system that determines the best location for product storage and a robot or machine that performs the physical movement of the product to the place previously determined, resulting in ISPP.

Tasks that cannot be specified precisely in a logical sequence of steps are called non-routine tasks. These tasks can be manual
or cognitive in nature. Among the cognitive ones, analytical tasks are those that depend on reasoning ability and creativity, such as the tasks performed by an educator. Since these activities depend on the creation of a new model or concept, the current technology does not allow their automation, which is usual in the service sector. However, informatics technology can complement educators’ task by providing computer systems to support them in creating new types of products, such as e-learning.

Still within the group of non-routine tasks, interactive tasks are those that depend on direct interaction with other agents, such as persuading customers to buy a certain product or coordinating the activities of subordinate employees. With regard to persuading a customer, currently there are a number of online shopping systems available for purchasing directly on the Internet, without the intervention of any sales agents. However, the process of persuading a customer to choose one product over another depends on several parameters beyond price and still cannot be automated fully using the current technology.

Another task group, although dependent on manual skills, does not follow a clear set of rules in the way in which it can be performed by informatics technology, since there are non-routine and manual tasks. One example is the case of driving a bus. Although drivers perform mostly manual tasks, the range of situations and non-standard events that can occur in traffic is so great that until now no one has been able to develop the software and robots capable of performing this task without jeopardizing the lives of passengers.

Therefore, given the existing relationship between informatics and the performance of different types of tasks, we wonder what is happening in the service sector with the spread of the use of this technology.

To understand the effect, first we have to define the link between workers’ skills and labor tasks. As defined by Acemoglu and Autor (2010), a task is a unit of work activity that produces an output. Skills are a worker’s stock of capabilities for performing various tasks, which means that low-skilled workers perform a subset of tasks that high-skilled workers carry out.

A change in technology, by the use of informatics for example, produces a reallocation of workers’ skills to different tasks. Workers migrate from tasks that are replaced by this technology to those that are not performed by computers or those that complement their use. This process tends to produce market polarization, because as workers are displaced from routine task-intensive occupations, a greater mass of skills is reallocated to the tail of the occupational skill distribution, both toward high-skill and problem-solving tasks and toward traditionally low-skill tasks, such as in-person service tasks (see Acemoglu and Autor, 2010, 2012).

However, notice that the routine-intensive tasks replaced by technology are heterogeneously distributed among the economic sectors, such as manufacturing and services. Thus, it is natural to expect different dynamics of changes in these sectors.

The following model aims to provide a theoretical foundation for the main effects on the labor market that the end of informatics law produced.

4.1. A simple task model

In this section we present the task model, based on Autor et al. (2003), to analyze the impact of the end of the Informatics Law on the Brazilian labor market.1

Like Autor et al. (2003), we make three assumptions concerning the interaction between computer capital and human labor input:

A1. Computer capital is more substitutable for human labor in routine tasks than non-routine tasks.

A2. Routine and non-routine tasks are themselves imperfect substitutes.

A3. A greater intensity of routine inputs increases the marginal productivity of non-routine inputs.

Consider a production model with two task inputs, routine and non-routine, that are used to produce the output Q that is sold at price equal to one per unit. Computer capital is a perfect substitute for human labor routine tasks.

For simplicity, we assume an aggregate Cobb–Douglas production function of the form:

\[ Q = (L_R + C)^{1 - \beta_k} L_R^{\beta_k}, \beta_k \in (0, 1), \]

where \( L_R \) and \( L_N \) are routine and non-routine labor and \( C \) is computer capital. Parameter \( \beta_k \) varies according to sector \( k \).

Without restrictions on computer capital, it is supplied perfectly elastically at market price \( p > 0 \) (and \( p < \infty \)). Under the restrictions imposed by the Informatics Law, we can assume that \( \hat{p} = \infty \), since it makes computer capital extremely high.

We assume that computer capital is a perfect substitute for labor that executes routine tasks. The Cobb–Douglas production function implies that the elasticity substitution between routine and non-routine tasks is one and therefore computer capital/routine tasks and non-routine tasks are relative complements.

There is a continuum of workers supplying one unit of labor. They have heterogeneous productivity endowments in routine (\( r_i \)) and non-routine (\( n_i \)) tasks with \( 1 \geq r_i, n_i > 0 \), \( \forall i \). A worker can choose to supply \( r_i, n_i \), or any convex combination of them \( (\lambda r_i + (1 - \lambda) n_i) \), with \( \lambda \in [0,1] \). These assumptions imply that workers choose tasks according to their comparative advantage and that the task supply will respond to the relative wage levels.

Under market equilibrium, given the perfect substitutability of computer capital and labor routine tasks, the wage per unit of routine tasks is pinned down by the price of computer capital:

\[ w_R = \rho. \]

In addition, workers’ occupation between routine and non-routine tasks clears the labor market. Let us define the relative efficiency of non-routine versus routine tasks for individual \( i \) as \( \eta_i = \frac{r_i}{n_i} \). Since we have a competitive labor market, the equilibrium is:

\[ \eta^* = \max \eta_i \rightarrow \eta^* = \frac{w_R}{w_N} \]

The individual supplies routine labor if \( \eta_i < \eta^* \) and non-routine labor if \( \eta_i > \eta^* \). The aggregated supply of routine and non-routine tasks is defined as \( g(\eta) \) and \( h(\eta) \), respectively, representing the sum of population endowments in units of routine and non-routine tasks at each value of \( \eta \). Therefore, we have:

\[ g(\eta) = \sum_i r_i \cdot I[\eta_i < \eta] \]

\[ h(\eta) = \sum_i n_i \cdot I[\eta_i > \eta] \]

where \( I[ \cdot ] \) is an indicator function.

In this model productive efficiency requires:

\[ w_R = \frac{\partial Q}{\partial R} = (1 - \beta_k) \theta^{\beta_k} \text{ and } w_N = \frac{\partial Q}{\partial N} = \beta_k \theta^{1 - \beta_k}, \]

\[ \]2

1 We use the same notation as Autor et al. (2003).

2 For more details see Autor et al. (2003).
where $\theta$ is the ratio of routine to non-routine task input $\theta = \frac{C \cdot g(\eta^*)}{\lambda \cdot D} \cdot \frac{\gamma}{p} \cdot \rho$.

Our goal is to analyze the changes in parameter $\rho$. The end of the Informatics Law produced a reduction in the price of computer capital. From Eq. (2) we can see that it had a direct effect on the wage of routine tasks.

The next step is to determine how the performance of routine and non-routine labor tasks responds to changes in the computer price. A reduction in the computer capital price $\rho$ increases the relative use of routine inputs in the production function, since

$$\frac{\partial \ln \theta}{\partial \ln \rho} = -\frac{1}{\rho_{K}} < 0.$$ 

However, since routine and non-routine labor tasks compete for time and since the increase in routine inputs raises the non-routine labor productivity, we expect an increase in non-routine wages relative to routine wages and a reallocation of labor from routine to non-routine labor tasks. We can see this statement by taking the elasticity between the wage ratio and the computer capital price:

$$\frac{\partial \ln \left( \frac{\rho_{K}}{\theta} \right)}{\ln \rho} = -\frac{1}{\rho_{K}} < 0.$$ 

This result shows that a reduction in the computer price increases the value of non-routine labor relative to routine labor. Finally, it is straightforward to see that more workers will perform non-routine tasks, since:

$$\frac{\partial \ln \eta^*}{\partial \ln \rho} = \frac{1}{\rho_{K}} > 0.$$ 

For a lower level of the computer capital price, the supply of labor changes. Since it reduces $\eta^*$, the supply of routine workers decreases, since $g(\eta^*) = \sum r_i \cdot I[\eta_i < \eta^*]$; on the other hand, the supply of non-routine workers increases, since $h(\eta^*) = \sum \eta_i \cdot I[\eta_i > \eta^*]$.

This effect gives support to our proposition 1:

**Proposition 1.** The dissemination of informatics technology produces changes in the performance of tasks.

Notice that sectors vary according to parameter $\beta$. The service sector is more intensive in non-routine tasks (higher $\beta_k$) and less sensitive to changes in the computer capital price $\left(\frac{\partial \ln \eta^*}{\partial \ln \rho} = \frac{1}{\rho_{K}} \cdot \beta_k\right)$.

This effect supports propositions 2 and 3:

**Proposition 2.** The dissemination of informatics technology produces different effects in service and non-service sectors.

**Proposition 3.** The dissemination of informatics technology has heterogeneous effects on service segments.

5. Data

We use two different data sources in this study (see Table 1). The information on the frequency of workers in each occupation and sector is from the Annual Social Information Report (Relação Anual de Informações Sociais – RAIS). This database is a record of employment in the formal market. According to the law enacted in 1975, all companies that operate in all sectors of the economy (agriculture, commerce, industry, and services, among others) must send these records annually to the Ministry of Labor, which organizes and disseminates them. It contains employment records disaggregated by regions, economic sectors, sizes of firms, occupations and so on. It has the advantage of covering almost all formal workers in the Brazilian market.

In this paper we analyze the demand for tasks in two periods of time: before and after the informatics technology dissemination in the Brazilian market. We choose 1985 as the ending point of the period when informatics technology did not have a significant impact on the Brazilian market. This is also the year with the oldest data available from the RAIS database, and, taking into account that personal computers only started to be sold in 1981 in the US and that the Informatics Law of 1984 controlled the importation and production of computers, we argue that this technology was not disseminated in the Brazilian market until 1985. Mainframe computers were available, but, due to their high prices, their use was restricted to a very small portion of the labor force, mostly in manufacturing segments. Between 1985 and 1992, local producers offered personal computers in the Brazilian market, but the adoption of this technology was limited to a small number of firms due to the high prices. According to the Brazilian magazine Info Exame published in June 1988, the prices of computers in Brazil were more than three times higher than those in international markets.

We compare the data from 1985 with the data from 2002. After the end of non-tariff barriers in October 1992, there was steep growth in computer use in Brazil (Botelho et al., 1999). However, this diffusion was highly uneven, with leading firms and advanced industrial sectors responding rapidly while smaller firms and peripheral regions remained marginal users of information technology (Botelho et al., 1999). In 2002, a decade after liberalization, informatics technology had been disseminated in all the sectors of the Brazilian market, allowing us to measure its effect.

From the RAIS database, we obtain information on the occupational frequency by sector. This data set provides information disaggregated by 25 economic sectors (see Table 1); 11 different sectors in service sectors and a further 14 non-service sectors that we use for comparison. 3

For the analysis of the impact of informatics technology on the service sector, we create a measure of the tasks carried out by workers and compute the changes in task demand over time (see Table 1). To measure tasks, we use our second source of data: the Brazilian Occupational Classification (Classificação Brasileira de Ocupações – CBO), also available from the Labor Ministry, published only in 1994 and 2002. This database describes the occupations and tasks performed by the employees who work in these occupations. For each occupation, a group of workers described the tasks that they perform and the resources that they need to perform them. The CBO follows the standards found in the International Standard Classification of Occupations (ISCO) from the United Nations, and it is a mandatory reference for administrative records for all companies in Brazil.

We use the most disaggregated occupational level available in the RAIS database (occupational families): a 3-digit code for CBO 1994, with 354 occupations; and a 4-digit code for CBO 2002, with 602 occupations. To compare the CBO 1994 and 2002 occupations, we use the conversion table published by the Labor Ministry, containing a total of 321 compatible occupations.

To investigate changes in the performance of tasks within each occupation, we take the CBO's occupational descriptions and classify each task according to the typology proposed by Autor et al. (2003). In this classification we use Table 2, aiming to maintain the standardization of task classification regardless of occupation. In this way we use Table 2 as a reference to ensure that, for example, the task “planning” is classified as non-routine analytical in all the occupations in which this task is performed. To illustrate the clas-

1 The service sectors are: Paper, publishing and graphics; Public services; Retail; Wholesale: Financial institutions; Professional and technical activities; Transport and communications; Hospitality services; Medical and dental activities; Education; Public administration.
Table 1
Variable description.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>RAIS</td>
<td>Services: paper, publishing and graphics; public services; retail; wholesale; financial institutions; professional and technical activities; transport and communications; hospitality services; medical and dental activities; education; public administration. Non-services: mining; non-metallic mineral products; metallurgy; mechanical and machinery; electronics; transport equipment; wood and furniture manufacturing; rubber, tobacco and leather; chemicals; textiles; shoes; food and beverages; construction; agriculture.</td>
</tr>
<tr>
<td>Pk</td>
<td>Calculation based on CBO</td>
<td>Proportion of each kind of task k per occupation o = number of tasks k in occupation o/total number of tasks in occupation o</td>
</tr>
<tr>
<td>N</td>
<td>RAIS</td>
<td>Total number of workers at a given time</td>
</tr>
<tr>
<td>Ns</td>
<td>RAIS</td>
<td>Number of workers in sector s</td>
</tr>
<tr>
<td>Ns</td>
<td>RAIS</td>
<td>Number of workers in occupation o</td>
</tr>
<tr>
<td>Tk</td>
<td>Calculation based on CBO and RAIS</td>
<td>Proportion of each kind of task k in the whole market at a given time = ( \sum \frac{P_{k,o} \times (N_s)}{(N_s)_{oc}} ) for all occupations o and all sectors s</td>
</tr>
<tr>
<td>Ts</td>
<td>Calculation based on CBO and RAIS</td>
<td>Percentage of tasks k in a given sector s, due to each occupation o/total number of tasks in the sector s</td>
</tr>
<tr>
<td>Co</td>
<td>CBO 2002</td>
<td>Dummy variable indicating whether or not computers are used in occupation o. Percentage of workers using computers in occupation o and sector s = ( \sum C_{o,s} ) for all occupations o</td>
</tr>
</tbody>
</table>

Table 2
Examples of the correspondence between tasks in CBO and the classification proposed by Spitz-Oener (2006).

<table>
<thead>
<tr>
<th>As proposed by Spitz-Oener (2006)</th>
<th>Correspondence in CBO</th>
</tr>
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<tbody>
<tr>
<td>NON-Routine Analytical</td>
<td></td>
</tr>
<tr>
<td>Researching</td>
<td>Researching, investigating</td>
</tr>
<tr>
<td>Analyzing</td>
<td>Analyzing, examining, studying</td>
</tr>
<tr>
<td>Evaluating and planning</td>
<td>Evaluating, planning, budgeting, making diagnoses, judging</td>
</tr>
<tr>
<td>NON-Routine Interactive</td>
<td></td>
</tr>
<tr>
<td>Negotiating</td>
<td>Negotiating, practicing law</td>
</tr>
<tr>
<td>Coordinating</td>
<td>Coordinating, leading people</td>
</tr>
<tr>
<td>Teaching or training</td>
<td>Teaching, training, spreading knowledge, instructing</td>
</tr>
<tr>
<td>Selling</td>
<td>Selling, marketing</td>
</tr>
<tr>
<td>ROUTINE COGNITIVE</td>
<td></td>
</tr>
<tr>
<td>Calculating</td>
<td>Calculating, programming, transforming</td>
</tr>
<tr>
<td>Bookkeeping</td>
<td>Bookkeeping, recording</td>
</tr>
<tr>
<td>Measuring</td>
<td>Measuring, verifying</td>
</tr>
<tr>
<td>ROUTINE MANUAL</td>
<td></td>
</tr>
<tr>
<td>Operating or controlling machines</td>
<td>Operating, distributing, transporting</td>
</tr>
<tr>
<td>Equipping machines</td>
<td>Equipping, assembling</td>
</tr>
<tr>
<td>NON-Routine Manual</td>
<td></td>
</tr>
<tr>
<td>Repairing or renovating</td>
<td>Repairing, renovating</td>
</tr>
<tr>
<td>Serving or accommodating</td>
<td>Serving, accommodating, cleaning</td>
</tr>
</tbody>
</table>

Table 3
Examples of tasks performed per occupation (receptionist).

<table>
<thead>
<tr>
<th>1994</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task</td>
<td>Type</td>
</tr>
<tr>
<td>Give information to visitors</td>
<td>Routine cognitive</td>
</tr>
<tr>
<td>Make appointments</td>
<td>Routine cognitive</td>
</tr>
<tr>
<td>Attend to visitors</td>
<td>Routine cognitive</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The proportion of tasks per sector in 2002 is calculated by merging the occupational frequency from RAIS 2002 and the proportion of tasks from CBO 2002. The proportion of tasks per sector in 1985 is calculated by merging the occupational frequency from RAIS 1985 and the proportion of tasks from CBO 1994. In the last case, the data available are not ideal due to the gap between 1985 and 1994, but CBO 1994 is the oldest source available.

Continuing the receptionist example, in 2002 there were 831,113 people working in the sector educational services, among whom 10,417 were receptionists. Thus, in 2002 the percentage of routine cognitive tasks in the occupation receptionist in the education sector was $T_{\text{Kos,2002}} = 100 \times 0.444 \times (10417/831113) = 0.557$. In 1985, among 152,787 people working in educational services, 1229 were receptionists. In 1994 the proportion of routine cognitive tasks in the occupation receptionist was 1.0 (see Table 3). Thus, in 1985 the percentage of routine cognitive tasks in the occupation receptionist was $T_{\text{Kos,1985}} = 100 \times 1.0 \times (1229/152787) = 0.804$. Finally, we calculate the difference between 1985 and 2002, $\Delta T_{\text{Kos,2002-1985}} = 0.557 - 0.804 = -0.247$. The negative sign means that the percentage of routine cognitive tasks performed by receptionists working in educational services in 2002 was smaller than that in 1985, meaning that the percentage of routine tasks in this occupation and sector decreased.

Lastly, with regard to our proxy for informatics technological change, we create a measure based on the resources used by professionals working in each occupation (CBO 2002). For occupations in which workers reported the use of computers in CBO 2002, we consider that all the workers in these occupations used computers. Then we calculate the percentage of workers using computers in a given combination of sector s and occupation o by dividing the number of employees working in occupation o (who use computers or not) in sector s by the total number of employees in sector s, called $C_{so}$.

The result of this exercise is a database containing the proportion of each kind of task demanding by a series of 321 occupations in 25 economic sectors, before and after the end of Brazilian market reserve policy. To summarize this dataset, differences among economic sectors are presented on Table 4, before and after the informatics law. The table shows the aggregated demand for each kind of task, for service and non-service sectors, as well as detailed information for eleven sub sectors of services.

The analysis of service sub sectors reveals the reduction on the proportion of manual routine tasks both in service and non-service sectors. This result is also evident on service sub sectors, except in two: financial institutions and education. In these two cases, the increase on demand for manual routine tasks can be a consequence of more controls introduced together with computers, such as new computerized management systems. All other service sub sectors show a decrease on demand for this kind of task, as expected, possibly as a consequence of automatic systems.

With regards to routine cognitive tasks, Table 4 shows an increase on demand for this kind of task for professionals in service and non-service sectors. However, among service sub sectors there are two exceptions: financial institutions and medical and dental activities. Routine cognitive tasks, such as make calculations, are intrinsic to these sub sectors, what suggests that computers provided conditions to automate these tasks, reducing the demand for professionals, consequently.

The analysis of Table 4 also shows the decrease on demand for non-routine manual tasks after the end of the market reserve policy in all sectors and sub sectors. Note that this kind of task represents a very small proportion of the total demand for tasks by the Brazilian market after the end of the policy. On the other hand, the proportion of non-routine analytical tasks increased substantially after the informatics law, in all sectors and sub sectors, mainly in education.

This finding supports the hypothesis that the spread of computers in the services sector has broadened the activities that require analytical capacity of service professionals in general.

Finally, the proportion of non-routine interactive tasks increased after the informatics law in service and non-service sectors. However, the proportion of interactive tasks decreased in two sub sectors: education and public administration. In education this result make sense, since teaching and training are inherent to this subsector and the introduction of computers contributed to the reduction of these tasks, since they can, partially, automate them (e-learning services, for instance). With regards to public administration, this decrease can be the result of the implementation of self-service systems, consequently diminishing the demand for face to face customer services.

6. Empirical approach and results

In this section we identify the effect of changes in the use of informatics technology on ISPP, represented by the changes in the use of different types of tasks.

To approach our problem empirically, we take advantage of the sudden end of the technological barrier imposed by the Brazilian Informatics Law, treating this event as a natural experiment to test our propositions. This law was enacted in 1984 to control the importation of computers with the purpose of nurturing a home-grown computer industry. With the end of this law in 1992, the use of computers increased sharply all over the country (see Botelho and Tigre, 1999).

Note that the end of the Informatics Law caused an exogenous and abrupt change in the use of informatics technology in Brazil. This event makes this country a good environment to test hypotheses concerning how a variation in informatics technology relates to changes in the performance of different types of tasks, representing ISPP, controlling for the unobserved heterogeneous characteristics of sectors and occupations.

To estimate this relation, we use a panel data regression model with one fixed effect on sectors to control for the heterogeneity across sectors and a second fixed effect on occupations to control for the heterogeneity across occupations. Thus, in a general way, the relation to be estimated is the following:

$$\text{Tasks}_{sot} = \theta_s + \gamma_o + \alpha_k t + \delta_0 t + \beta_k \text{Change Computers}_{sot} + \epsilon_{sot}$$

where $\theta$ and $\gamma$ are sectors’ and occupations’ fixed effects on the level, $\alpha$ and $\delta$ are fixed effects on the trend for sectors and occupations and $\beta_k$ is the effect of computers on the percentage of tasks.

Parameters $\theta$ and $\gamma$ control for the unobservable characteristics of sectors and occupations, respectively, which are constant through time, while $\alpha$ and $\delta$ represent the control for the unobservable constant tendencies of sectors and occupations, respectively. Using these fixed effects, we can control for specific characteristics of sectors and occupations and their changes over time.

Taking the first difference in $t$ of the equation, we have:

$$\text{Changes}_{\text{Tasks}}_{sot} = \alpha_k + \delta_0 + \beta_k \text{Changes Computers}_{sot} + \epsilon_{sot}$$

If we find a value of $\beta_k$ different from zero, it means that changes in the use of informatics technology affected the performance of tasks and hence there is evidence of ISPP. Otherwise, if the estimated value of $\beta_k$ is zero, it means that the use of informatics technology did not translate into ISPP.

In the remainder of this section, we first examine how the demand for different types of tasks changed due to informatics technological changes, measured by the use of informatics technology, in the service sector. Then, in subsection 6.2 we compare the effect of informatics technology on different types of tasks between
Table 4
Demand for tasks in service sectors.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>NA (%)</th>
<th>NI (%)</th>
<th>RC (%)</th>
<th>RM (%)</th>
<th>NM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Services sector – Total</td>
<td>8.14</td>
<td>14.74</td>
<td>23.04</td>
<td>25.39</td>
<td>29.10</td>
</tr>
<tr>
<td>Non-services sector – Total</td>
<td>4.49</td>
<td>11.59</td>
<td>4.46</td>
<td>11.09</td>
<td>18.63</td>
</tr>
<tr>
<td>Services’ sub sectors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Publishing and graphics</td>
<td>8.09</td>
<td>15.76</td>
<td>6.36</td>
<td>13.91</td>
<td>27.41</td>
</tr>
<tr>
<td>Public services</td>
<td>9.54</td>
<td>12.27</td>
<td>9.92</td>
<td>12.62</td>
<td>46.84</td>
</tr>
<tr>
<td>Retail</td>
<td>4.57</td>
<td>7.07</td>
<td>20.12</td>
<td>29.99</td>
<td>23.30</td>
</tr>
<tr>
<td>Wholesale</td>
<td>5.76</td>
<td>8.18</td>
<td>15.74</td>
<td>24.10</td>
<td>26.16</td>
</tr>
<tr>
<td>Professional and technical activities</td>
<td>7.66</td>
<td>12.88</td>
<td>8.25</td>
<td>21.51</td>
<td>34.78</td>
</tr>
<tr>
<td>Transport and communications</td>
<td>6.04</td>
<td>7.98</td>
<td>4.76</td>
<td>14.53</td>
<td>32.22</td>
</tr>
<tr>
<td>Hospitality services</td>
<td>9.48</td>
<td>15.66</td>
<td>15.52</td>
<td>19.08</td>
<td>21.61</td>
</tr>
<tr>
<td>Medical and dental activities</td>
<td>8.29</td>
<td>15.17</td>
<td>19.80</td>
<td>39.28</td>
<td>39.49</td>
</tr>
<tr>
<td>Education</td>
<td>8.22</td>
<td>27.39</td>
<td>56.70</td>
<td>20.89</td>
<td>14.92</td>
</tr>
<tr>
<td>Public administration</td>
<td>9.00</td>
<td>20.89</td>
<td>45.13</td>
<td>26.78</td>
<td>21.59</td>
</tr>
</tbody>
</table>


service and non-service sectors. Finally, subsection 6.3 analyzes the heterogeneity of the impact of informatics technology on different segments within the service sector.

6.1. The use of informatics technology and changes in task demand

We start the discussion about the effects of informatics technology by presenting the change in the performance of tasks in the Brazilian market (ΔTk). Fig. 1 illustrates the changes between 1985 and 2002 for service segments. It shows that in 1985 the tasks that were most in demand were routine cognitive ones, representing almost 30% of the total share, followed by routine manual tasks with 27%. As expected, the demand for routine manual tasks fell sharply during this period. However, the routine cognitive tasks increased from 30% to 40% of the total tasks demanded in the Brazilian market, pointing to changes in the service production process, which configures ISPP (Vence and Trigo, 2009).

With regard to non-routine tasks, Fig. 1 shows an increase from 23% to 25% in the demand for interactive tasks and from 8% to 15% in the demand for analytical tasks, both results as expected from the theoretical model. There was also a sharp decrease in manual tasks from 12% in 1985 to only 2% in 2002.

Now we verify whether these changes were really caused by the dissemination of informatics technology. We argue that the shift toward informatics technology usage raised the demand for non-routine tasks (skilled workers) and reduced or had no effect on the demand for routine tasks (low-skilled workers) in a given service-type occupation. To verify this statement, we test the following statistical model, using the fixed effects on service activities and occupation:

\[ ΔT_{kso,1985−2002} = α_s + δ_0 + β_k \cdot C_{so,2002} + ε_{so} \]  

(1)

where \( ΔT_{kso,1985−2002} \) represents the difference in the percentage of tasks k, per occupation o and service activity s, between 1985 and 2002, and \( C_{so,2002} \) is the percentage of workers using computers in 2002 in occupation o and service activity s.

The results presented in Table 5 show a positive relationship between the use of informatics technology and non-routine analytical tasks, which means ISPP (Djellal and Gallouj, 2007). Nonetheless, these results are not statistically significant for non-routine interactive and manual tasks and for all types of routine tasks.

These results confirm that ISPP occurred in the Brazilian service sector. Furthermore, the source of innovation was the increase in non-routine tasks. This empirical result is aligned with Evangelista and Savona (2003) and Toivonen and Tuominen (2009). These authors argue that the use of technology improves the service production process, demanding non-routine tasks from workers and automating routine ones. The result is also aligned with Acemoglu and Autor’s (2010) theoretical model that argues that the use of informatics technology produces a reallocation of workers’ skills to different tasks.

Notice that we use the end of informatics’ law as natural experiment to take advantage of its exogenous nature. This exogenous shock gave us the chance to estimate the effect of changes in technology without the econometric concern of endogeneity problem (and its consequence: the inconsistency of estimated parameters). In addition, the huge change in technology exacerbates its effect on innovation and labor market. For these reasons, and because we do not have a recent natural experiment to take advantage, we have to use outdated data. On the other hand, the effect of a current change in technology on the dynamics of labor tasks could be different from our findings. We could expect a marginal lower (negative) effect on routine tasks since its use dropped after the end of Informatics Law.

6.2. The effect of informatics technology on the service and non-service sectors

Changes in informatics technology can modify the formal employment structure, motivating migration between sectors (see Acemoglu and Autor, 2010). To understand such dynamics between sectors in the labor market, in this section we compare the effect of the use of computers in two sectors: the service sector and the non-service sector.

To verify the heterogeneous effect of the use of computers on the demand for tasks in the service and non-service sectors, we carry out two extensions: first, the sample is composed of all the sectors in the economy, not only the service sector; second, the model presented in Eq. (1) is extended by adding the interaction of the service sector dummy (represented by D_Service) with the computer use variable. Eq. (2) presents the specification:

\[ ΔT_{kso,1985−2002} = α_s + δ_0 + β_k C_{so,2002} + \phi_{D_Service} \cdot C_{so,2002} + ε_{so} \]  

(2)

where \( ΔT_{kso,1985−2002} \) represents the difference in the percentage of tasks k, per occupation o and sector s, between 1985 and 2002, \( C_{so,2002} \) is the percentage of workers using informatics technology in 2002 in occupation o and sector s and \( D_Service \times C_{so,2002} \) is the interaction term between the service sector dummy and the use of informatics technology.

The estimated effect of the use of informatics technology on the tasks demanded by the non-service sector is represented by param-
Table 5
Effects of innovation on the demand for tasks in the service sector.

<table>
<thead>
<tr>
<th></th>
<th>NA</th>
<th>NI</th>
<th>NM</th>
<th>NRTS</th>
<th>RM</th>
<th>RC</th>
<th>RTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of computers</td>
<td>0.136***</td>
<td>−0.014</td>
<td>−0.008</td>
<td>0.113</td>
<td>−0.064</td>
<td>−0.093</td>
<td>−0.156</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.889]</td>
<td>[0.072]</td>
<td>[0.286]</td>
<td>[0.582]</td>
<td>[0.671]</td>
<td>[0.254]</td>
</tr>
<tr>
<td>R²</td>
<td>0.516</td>
<td>0.251</td>
<td>0.415</td>
<td>0.368</td>
<td>0.404</td>
<td>0.447</td>
<td>0.473</td>
</tr>
<tr>
<td>Prob &gt; F</td>
<td>0.000</td>
<td>0.000</td>
<td>0.776</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note 1: **, *** denote the significance levels of 5% and 1%, respectively. Constant suppressed.
Number of observations: 3531 (11 service activities × 321 occupations).

Despite the absence of an effect of innovation on the other types of tasks in the service sector, evidenced in the third line of Table 5 ($\beta_1 + \phi_1$), the same pattern does not hold for the non-service sector. Beside the huge increase in non-routine analytical tasks (0.68), which boosted non-routine overall (0.68), the non-service sector experienced a significant reduction in routine tasks (−0.655) due to routine manual tasks (0.706). None of these effects on routine tasks are evidenced in the service sector, which is expected since automation is almost nil compared with the non-service sector (Eliche and González, 2008). The use of informatics technology in the service sector does not exclude the use of human work; rather, it complements humans (Planta, 2005) and improves the service production process, called innovation (Sirilli and Evangelista, 1998).

6.3. The heterogeneous effect of informatics technology in the service sector

Finally, to investigate the effects of informatics technology in the service sector in greater depth, we explore the effects in each segment within the sector. The service sector is composed of 11 types of services: publishing and graphics; public services; retail; wholesale; financial institutions; professional and technical activities; transport and communications; hospitality services; medical and dental activities; education; and public administration.

To verify the heterogeneous effect of the use of informatics technology on the demand for tasks in the service sector, we extend our model, represented by Eq. (1), by adding the interaction of dummies representing each activity (represented by D_Service) with the informatics use variable. Eq. (3) presents the specification:

$$\Delta T_{kso, 1985−2002} = \alpha + \delta + \beta_k C_{so, 2002} + \phi_j$$
Table 6
Effect of innovation on service vs. manufacturing sector.

<table>
<thead>
<tr>
<th></th>
<th>NA</th>
<th>NI</th>
<th>NM</th>
<th>NRTS</th>
<th>RC</th>
<th>RM</th>
<th>RTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computers</td>
<td>0.68***</td>
<td>0.009</td>
<td>0.001</td>
<td>0.689***</td>
<td>0.05</td>
<td>−0.706***</td>
<td>−0.655***</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.346]</td>
<td>[0.760]</td>
<td>[0.000]</td>
<td>[0.246]</td>
<td>[0.000]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>Comput. × D_Service</td>
<td>0.151***</td>
<td>0.011</td>
<td>0.007</td>
<td>0.530***</td>
<td>0.168</td>
<td>0.608***</td>
<td>0.440***</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.910]</td>
<td>[0.104]</td>
<td>[0.000]</td>
<td>[0.434]</td>
<td>[0.000]</td>
<td>[0.001]</td>
</tr>
<tr>
<td>β₁ + φ₁</td>
<td>&gt;0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>[0.000]</td>
<td>[0.981]</td>
<td>[0.121]</td>
<td>[0.129]</td>
<td>[0.584]</td>
<td>[0.353]</td>
<td>[0.1162]</td>
</tr>
<tr>
<td>R²</td>
<td>0.827</td>
<td>0.163</td>
<td>0.333</td>
<td>0.428</td>
<td>0.346</td>
<td>0.72</td>
<td>0.746</td>
</tr>
<tr>
<td>Prob&gt;F</td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
<td>[0.000]</td>
</tr>
</tbody>
</table>


Note 1: **, *** denote the significance levels 5% and 1%, respectively. The tests for non-routine manual tasks were not significant and are omitted from this table.


Number of observations 8025 (25 industries × 321 occupations).

\[
\sum_{j} D_{\text{Service}_j} \times C_{10,2002} + \varepsilon_k
\]

where \( \Delta T_{\text{obs,1985-2002}} \) represents the difference in the number of sales, year to year \( k \), and the service sector, \( s \); between years 1985 and 2002, \( C_{10,2002} \) is the percentage of workers using informatics technology in 2002 in occupation \( o \), sector \( s \), and \( D_{\text{Service}_j} \times C_{10,2002} \) is the interaction term between the service segment dummy and the use of informatics technology. We leave public services in the constant term, so all the effects are represented by the sum of parameters \( \beta_k \) and \( \phi_k \).

The results presented in Table 7 show the heterogeneous effect that informatics technology had on different segments in the service sector. Note that, although the macro-level effect in the service sector is shown only in non-routine analytical tasks, there was a micro-level effect on almost all kinds of tasks if we look specifically at each activity, since there are differences within the service sector (Miles, 1993).

Concerning the effect on public services (represented by parameter \( \beta_k \)), the non-routine analytical tasks – such as planning, budgeting and analyzing – were positively affected by the use of computers, creating innovations that improved the services. In public administration activities, we evidence that non-routine interactive tasks, such as coordination, instruction, training and leading people, tended to be mitigated. On the other hand, routine cognitive tasks (such as measuring, calculating and programming), routine manual tasks (operating) and non-routine analytical tasks (such as planning, budgeting and analyzing) received a positive impact from the use of informatics technology.

In professional and technical services and medical services, the performance of non-routine interactive and analytical tasks (such as coordination, training, leading people, planning, budgeting and analyzing) tended to increase with the use of informatics technology, changing the service production process. We can also see a reduction in the performance of non-routine manual tasks in professional and technical services.

For the hospitality services, we can notice a reduction in non-routine manual tasks, such as cleaning, meaning that the service tended to be automated, reducing its heterogeneity. Wholesale, retail and transportation services show similar behavior, with a small or no effect on non-routine analytical tasks (planning, budgeting and analyzing). This is evidenced by the sum of \( \beta_k \) and \( \phi_k \). Except for wholesale activity, there was an increase in routine manual tasks, such as operating equipment. On the other hand, transportation and communication experienced an increase in non-routine interactive tasks (such as coordinating, leading people and instructing), differing from wholesale and retail, which presented an increase in routine cognitive tasks (such as measuring, calculating and programming).

Regarding financial services, we observe that financial institutions increased the use of non-routine interactive tasks, mainly selling and marketing, and routine manual tasks (operating). However, there was a reduction in routine cognitive tasks, such as measuring, calculating and programming, indicating task automation.

Finally, Table 7 shows that the activities of publishing and graphics followed the sector average, with an effect of the use of informatics technology only in non-routine analytical tasks. On the other hand, in education services almost all types of tasks were affected by the use of informatics technology, significantly changing their production process.

In sum, the use of informatics technology causes ISPP, and each type of activity is affected in a different way, according to its own characteristics.

7. Conclusion

With economic development, the size of the service sector tends to increase in relation to the other sectors. With its increasing relevance, the impact of innovation in this sector deserves careful investigation. However, innovation in the service sector is usually difficult to evidence directly due to the labor-intensive characteristics. Thus, to show innovations in the service production process, we looked at indirect evidence of this phenomenon.

Our investigation focused on changes in the tasks performed by workers as a consequence of the more intensive use of informatics technology in the service sector. To answer our main question, we used a Brazilian data set with information on tasks carried out by workers in all sectors of the economy. First, we focused on data relative to the service sector. We evidenced that in general the use of informatics technology has had a positive effect on non-routine analytical tasks, such as planning, researching and budgeting, among others. This result shows that the use of informatics technology contributes to innovation in the service production process, expanding the performance of non-routine tasks in the service sector.

Comparing the effect on the service sector with the effect on the non-service sector provided a broader view of the changes from the use of informatics technology. As a result, we concluded that automation is less present in the service sector than in the non-service sector, as stated by Elche and González (2008). Also, according to Collier (1983), the use of informatics technology is

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4 Our choice to leave the Public services in the constant term was ad hoc; there is no theoretical reason for our choice.
more evident in the non-service sector. Thus, we determined that the use of informatics technology in the service sector does not destroy jobs, as observed in the non-service sectors, but instead complements the use of human capital. Thus, it improves the service provided by firms, resulting in innovation. This result is aligned with Pianta (2005) and Sirilli and Evangelista (1998).

Finally, we analyzed the heterogeneous effect of the use of informatics technology on different activities in the service sector. We can conclude that all the activities that compose the service sector are affected by the use of informatics technology but in different ways, explained by their peculiarities.

In terms of policy it is a very relevant instrument. It can orient government strategies to subsidize and invest in the labor market to facilitate the flow of workers between jobs that entail different types of tasks. It can also orient companies’ strategies for training people for specific tasks as a complementary effort to informatics technology implementation.

Therefore, we contribute to the empirical literature by evidencing the innovation aspects of the production of services, something that is rare in the service literature. However, we should mention some limitations. First, our experiment was restricted to a single setting, Brazil. Second, our information on workers’ occupation concerned only two points in time (1994 and 2002) and came from codes that are not perfectly matched. Finally, our database is quite old, due to the time that has passed since the change in policy. Still, we believe that the general patterns observed in the period before and after this change in Brazil hold true today.

For future studies, we suggest conducting the same analysis but considering exclusively KIBSs (knowledge-intensive business services) and a comparison of this segment with other traditional service sectors, like transportation, retail, wholesale and others.

Acknowledgements

We would like to thank Klenio Barbosa, Sergio Firpo, Cristina Terra and the editor, Luigi Marengo. We would also like to thank seminar participants at EESP/FGV-SP and 2011 Brazilian Meeting of Economics. We are also indebted to an anonymous referee, whose comments greatly contributed to strengthen this text. The authors acknowledge financial support from CNPq.

References


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