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THE IMPACT OF PHYSICIANS' DECENTRALIZATION ON HEALTH SERVICES AND ECONOMIC GROWTH*

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ABSTRACT: This study uses Zon and Muijen's (2001) model to investigate the effect of physicians' decentralization on health care production, human capital accumulation, and economic growth. The model includes the health, education, and production sectors, and was calibrated for the Brazilian economy in 2014 with data from National Accounts, the Census and the Brazilian National Health System SUS. The aim was to estimate the impact of the change in the number of physicians per 100,000 inhabitants. We considered four different groups: municipalities with above and below 50,000 inhabitants in the south and southeast of Brazil and similarly for the north and northeast regions of the country. Our results indicate that increasing the number of physicians per 100,000 inhabitants raises the economy's long-term growth rate, improves the average quality of health, and increases the proportion of effective labor in the production of human capital.

Keywords: Health status; Physician; Decentralization; Economic growth.

JEL Codes: I18; C21.

O IMPACTO DA DESCENTRALIZAÇÃO DOS MÉDICOS SOBRE OS SERVIÇOS DE SAÚDE E O CRESCIMENTO ECONÔMICO

RESUMO: O trabalho utiliza o modelo de Zon e Muijen (2001) para investigar o efeito da descentralização de médicos por habitante sobre a produção de serviços de saúde, a acumulação de capital humano e o crescimento econômico. O modelo inclui os setores de saúde, educação e produção de outros bens e foi calibrado para a economia brasileira em 2014 com dados das Contas Nacionais, do Censo e do Sistema Único de Saúde (SUS). O objetivo é o de estimar o impacto da mudança no número de médicos por 100.000 habitantes. Foram considerados quatro grupos diferentes: municípios com mais e menos de 50.000 habitantes no Sul e Sudeste do Brasil e de maneira similar para as regiões Norte e Nordeste do país. Os resultados indicam que aumentar a razão de médicos por 100.000 habitantes favorece o crescimento econômico de longo prazo, melhora a qualidade média da saúde e aumenta a proporção do trabalho efetivo na produção de capital humano.

Palavras-Chave: Saúde; Médicos; Descentralização; Crescimento econômico.

Classificação JEL: I18; C21.

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1. Introduction

The theory of endogenous growth suggests the integration of health production and economic growth through the accumulation of human capital. A decrease in growth may be explained by health preferences that are positively influenced by a rising per capita income or by having many physicians within a country. Growth may even disappear in countries with high rates of health deterioration or low productivity in the health sector (ZON; MUYSKEN, 2001).

On the other hand, if the health sector is dynamic, economic growth will be favored both by technological progress in this sector and by better access to the health for the workforce. Health and education are important factors for development as they affect the production capacity of individuals. The decentralization of physicians from larger municipalities to smaller ones has the potential to impact the nation's health and wellbeing. The more qualified and healthier, the more productive are the workers, and consequently the higher the income of the economy, with more physicians available to attend to the population. Thus, the latter will have more accessible healthcare.

It is no coincidence, therefore, that education and health expenditures are two of the most representative items of public spending in the developed world. Education expenditure in the Organisation for Economic Co-Operation and Development (OECD) accounted for 5.2% of the gross domestic product (GDP), with 4.5% of the GDP financed by the public sector, whereas health costs are approximately 6% of the GDP (WORLD BANK, 2014).

The literature on economic growth has given priority to education because of its more direct correlation with development in papers like Baumol (1967), Lucas (1988), Romer (1990), and Barro and Sala-i-Martin (1995). More recently, however, health has attracted attention because of its rising costs associated with aging; therefore, there is a greater need for more physicians to attend to this aging population. Thus, not only education, but also health is important for economic growth.

According to the endogenous growth model of Lucas (1988), education impacts the formation of human capital for growth and development. However, for people to provide effective human capital services, they must be healthy. Therefore, the health of the population in general influences everyone's growth and well-being. Health care enhances well-being and economic performance because healthy people increase labor productivity.

This study uses Zon and Muiyken's (2001) model to investigate the effect of physicians' decentralization of health care production, human capital accumulation, and economic growth. The model, therefore, includes a health, education, and production sector. All three sectors are interrelated, since the overall level of health affects workers and the accumulation of human capital, while a higher level of human capital is related to better quality of health. Finally, health and human capital affect the output of the economy.

The results appear to be positive from the perspective of economic growth. When the number of physicians per inhabitant increases, the higher labor availability raises productivity in the health sector, which ultimately improves labor productivity, resulting in increased capital accumulation and economic growth. On the other hand, it is estimated that a reduction in the propensity to consume when there is a higher portion of the labor force in the health sector, that is, when the number of physicians per inhabitant increases.

This article is organized into seven sections, including this introduction. The second section presents a literature review on decentralization, whereas the third on economic growth and health. The fourth section introduces the endogenous growth model used in the study. The fifth section shows the model calibration performed to reflect how the variation of the number physicians per inhabitant affected the Brazilian economy in 2014. The sixth section presents the results and the seventh section the final considerations and policy suggestions.

2. Decentralization and health

In recent years, the tendency of decentralization of public expenses has increased, because of its relationship with the decrease in public spending (DONAHUE, 1997). With decentralization, the

local institutions have more detailed information about the region's inhabitants. The public policies applied may be more efficient because they are directed to the local population's preferences and necessities.

Even if the federal government wants to decentralize its responsibilities to the state governments, the latter want the opposite. The equilibrium between the two will depend on government legitimacy and on how strong the institutions are (RODRÍGUEZ-POSE; GILL, 2003). In addition to the fact that strong or weak institutions affect the development of countries differently (NORTH, 1991) verified empirically for a variety of nations (ACEMOGLU; JOHSON; ROBINSON, 2001), the culture also influences economic growth. The culture presents a causality effect in economic development according to data analyzed from European regions (TABELLINI, 2010). Another important factor is that political institutions affect corruption levels, and therefore, economic growth (FERRAZ; FINAN, 2010).

Central government funds' transfers to local government increase public spending more than private income (MATTOS; ROCHA; ARVATE, 2011). This phenomenon is known as flypaper: higher transfers can induce less efficiency in collecting taxes than increases in income. Therefore, the public finance empirical literature identified the flypaper effect around the 1970s, according to Mendes and Rocha (2004). This effect is the receiving of lump sum fiscal transfers from subnational governments, which implies an increase in local public spending proportionally greater than the one that would be generated by an equivalent increase in personal income. Decentralization presents difficulties, such as externalities, "tax war," and tribute exportation. Then, fiscal transfers from higher to lower government levels appeared as an important tool in a vertical and horizontal solution to imbalances, in addition to the correction of externalities.

The effect of decentralization of public spending on health has been studied in various countries. According to Kruse et al. (2009), in Indonesia, municipalities' decentralization decreases public health spending. Besides the spending, how the government allocated its resources is very relevant. Further, public policies in the health sector will differ among municipalities; especially when these policies are directed to the population with the lowest incomes, the effect of decentralization is related to the allocation of scarce resources.

Kruse et al. (2009) suggested that this effect is being observed throughout different developing countries with a high number of poor families. The management of these sources will have a positive or negative impact on the families who need basic help the most. Like in Indonesia, the municipalities in Brazil have a legal responsibility to guarantee primary care for their population; however, there is freedom to decide what taxes should be directed to public health services. Additionally, these municipalities are not legally required to justify to the central government how their money is spent; the justification is given to the municipalities' parliament.

Meanwhile, in Brazil, there is a significant amount of bureaucracy, with resources locked and detailed. By locked, we mean that when the resources are received from the union, it is already predetermined where the spending will be allocated; there is no freedom to allocate the money in the most efficient way by municipality's manager. One of the consequences is difficulty managing health public spending. Naturally, the manager's ability to manage influences the allocation of the resources, even with all the bureaucracy, although the corruption within the country greatly increases the inefficiency of public health spending. Further, the lack of punishment for the politicians who steal money from the people negatively impacts the money allocation. Therefore, public health, which is very important to the nation's development, is negatively impacted by these factors. According to Mosca (2007), decentralization is a public spending determinant; territorial decentralization involves responsibilities' transfers from the central government to lower government.

In recent years, decentralization is more frequently studied in the literature. Within the decentralization context, "economic dividend" provides economic advantages in the transfer of power from national institutions to lower government levels (RODRIGUEZ-POSE; GILL, 2005). This economic dividend stems from the decentralized administrations' ability to adapt public policies to local needs, generating innovation in the provision of service through intra-territorial competition, and also stimulating participation and accountability decreasing the distance between the ones in

power and their constituencies. Some governmental systems may have negative consequences on economic allocation. Gains and losses that devolution can generate are contingent on what government level is being responsible for a public policy.

The subject of devolution is also explored by other authors. The capacity of regional devolution to overcome the democratic deficit and to introduce a more effective government is observed by Morgan (2002). The author's paper supports the hypothesis that the Northern regions in England would present a positive economic dividend. Local government regulation may provide better results in economic development compared to higher levels of government (JONES, 2001), which means political interventions managed by municipalities or states offer more positive results than the central government. The idea of managing a municipality locally is becoming more accepted among policy makers and scholars, in order to equalize the economies' deficit on a regional scale. On the other hand, decentralization of power is giving politicians incentives to make political decisions strategically in order for them to obtain more power, rather than to solve the economic deficit problem.

Aiming to highlight government quality, Rothstein and Teorell (2008) propose a coherent and specific definition of government quality, with the impartiality of institutions that have the government's authority. The motivation for such a study is the fact that a government with strong institutions tends to influence economic growth positively, as observed empirically. The idea of impartiality is related to a series of critics in public management, public choice, multiculturalism, and feminism. The theory of impartiality is observed in a general context of government quality, such as democracy, rule, law, efficiency, and accuracy.

The application of such a theory is studied by Charron, Dijkstra and Lapuente (2014). To measure government quality, the authors use what is known as the "European QoG Index." Good government quality is understood to represent a low corruption index, impartial public services, and rule of law. Empirically, twenty-seven countries in the European Union were studied, at the national and lower levels of government. In this study, Italy and Spain evidenced better government quality than that of the other nations.

To analyze government quality and investment return, Rodríguez-Pose and Garcilazo (2015) examine the relationship between local and regional government quality, and regional economic performance, relating government quality with a return fund in the European Union. It was possible to analyze the importance of government quality as a determinant of economic growth, in addition to the efficiency of structural public spending. As a result, he observed that better government quality is more important to regional development than additional public investment.

Corruption affects the allocation of resources in different countries, especially in Brazil. With this in mind, Ferraz and Finan (2008) measure the audits' effects, finished and published in the election results. According to the authors, during 2003, the Brazilian federal government started to select municipalities randomly to audit their spending, with resources from the federal transfer. This auditing was part of a national program against corruption and its outcomes were released publicly. Comparing the election results of audited municipalities before versus after the 2004 election, with the same level of reported corruption, it was evidenced that the audit had a significant impact in the elections. As a result, it was possible to observe that a more informed electorate, in addition to the present media, such as the radio that released the audit results, plays an important role in the election.

Still, the government revenue and political corruption are evidenced in the work of Brollo (2010). The authors observed that federal transfers to government municipalities change according to the population. To measure the causality effect of higher federal transfers on political corruption and characteristics of political candidates at the local level, they used a discontinuity regression. As a result, according to their theory, higher transfers increase political corruption and decrease the quality of candidates running for mayor.

How the money is allocated to the health sector is extremely important, because good health care contributes to individuals' well-being. The health sector directly affects the economy, and increases in health expenses have created great challenges, even for countries with a high quality of life (PHELPS, 2016). With decentralization in mind, in addition to health expenses, the number of

decentralized physicians may increase a nation's health quality. Thus, allocating physicians from capital cities to small municipalities will provide an opportunity for the poor families to have basic health care. Until the middle of the last century there was no health system in Brazil. Only the rich families were treated in private institutions. However, with Sistema Único de Saúde (SUS), a unique health system was founded and guaranteed by the Federal Brazilian Constitution of 1988, a universal, free public health system. Especially, Programa Saúde da Família (PSF) is a program that gives primary care to almost every single municipality in the nation, which comprises 5,295 municipalities. One of the positive results was that mortality by infectious diseases decreased from 23% of total deaths in 1970 to less than 4% in 2007. Despite some of SUS's successes, there are serious problems such as lack of investment, corruption, mismanagement, and lack of human resources, especially physicians (ALMEIDA-FILHO, 2011).

3. Economic growth and health

Health has been a priority in the public and private expenditures of developed countries. According to OECD (2016), on average, the countries in the organization spent 9% of their GDP on health in 2015, with the highest spending in the United States (16.9% of GDP), Switzerland (11.5% of GDP), and Japan (11.2% of GDP). Brazilian numbers are very close to the average for rich countries. According to OECD (2015), Brazil spent 9.1% of its GDP in 2013 on health.

However, given income differences, per capita expenditure in US dollars is much higher in OECD than in Brazil. In 2015, the average per capita expenditure in OECD reached US\$ 3,815, whereas in Brazil it was only US\$ 1,471 in 2013.

The public sector is the main funder of health spending. In OECD, of the 9% of GDP earmarked for health, 73% comes from governments (6.6% of GDP). Thus, 15% of all OECD public spending goes to the health sector. In Brazil, 46% of the health spending was financed by public resources in 2012, so the health sector accounted for only 7.9% of the total public spending in that year (WHO, 2015).

Health has therefore played a central role in both government and household spending. One of the main theoretical motivations for public spending on health is related to the economy. The hypothesis is that a healthy population will be more productive and capable of generating more wealth for the country. However, it took time for health to be considered an important factor for economic growth. It is only in the twenty-first century that the subject has become a central one for growth economists.

Initially, health was incorporated in growth models through human capital. Health affects labor supply, either through working hours or labor market participation. The consequence of this modeling strategy is predictable: the higher the overall health, the greater the human capital and the higher the rate of economic growth. Good health is important to sustain high levels of human capital, with positive effects on productivity and growth (LOPEZ; RIVERA; CURRAIS, 2005). A healthy workforce would be less prone to disease and more willing to work. Raising productivity by improving workers' health would be greater for manual workers, so an increase in health care services may have a particularly significant impact on the growth rates of less developed countries.

The second connection between health and growth is demography. Improved health not only allows an increase in life expectancy but also an increase in the number of productive years for each worker. On the other hand, better health means reducing child mortality. Considering these two effects, health improvement helps population growth, one of the foundations of economic growth. Still, in the same vein, better health also favors growth by increasing life expectancy, which encourages the population to save more, with positive effects on capital accumulation (WEIL, 2005).

Positive externalities associated with health also impact economic growth. An individual's level of health does not only depend on whether he or she cares for himself or herself, but also depends on the general state of health in the entire population. Low levels in the general health of the population can not only reduce human capital but also negatively influence production, reducing investment and the accumulation of physical capital. Lucas's (1988) model, although not directly concerned with

health, has been the most relevant theoretical basis in the development of endogenous growth models related to health.

However, the literature is not unanimous regarding the positive relationship between health and growth. Zon and Muysken (2001) argue that the health sector is not a productive activity and that it competes with production activities for scarce resources in the economy. They suggest that when health is incorporated in the utility function, the relationship between health and economic growth may be negative.

Empirical analysis reinforces the relationship between growth and health. Studies with a panel of countries for the period between 1960 and 1985, found a positive correlation between health and economic growth, for example, both Knowles and Owen (1995) and Mankiw et al. (1992). Similar models, such as those by Rivera and Currais (1999) and Hashamati (2001), suggest that health spending has a positive impact on growth in OECD countries. Another study with a panel of countries for the period between 1960 and 1990 concluded that good health has a positive and statistically significant impact on aggregate output (BLOOM; CANNING; SEVILLA, 2004). A similar result was found in Latin America, in the relation between the composition of public expenditures and the economic growth of Latin American countries between 2000 and 2010. The countries that allocated more resources to health had higher rates of growth (MACÊDO; BEUREN, 2013).

In the national literature, two papers found completely different results: Mora and Barona (2000) and Cermeño (2000). Both studies estimate the relation between growth and health for the Brazilian states. Mora and Barona (2000) use the Barro model (1996) and Cermeño (2000) the model of Mankiw, Romer, and Weil (1992). Interestingly, Mora and Barona (2000) found a negative relationship between growth and health, whereas Cermeño (2000) suggested a positive relationship between the two variables. Another study, Figueiredo et al. (2003), investigated whether health status impacted Brazilian economic growth in the 1990s, based on an econometric estimation of the Solow model (1956). According to the results of the study, health status contributes directly and positively to economic growth but also influences the accumulation of human capital. A worsening health status tends to reduce the positive impact of education on growth.

The present study contributes to the Brazilian literature by analyzing the influence of the health sector on growth with an endogenous growth model. The national literature has focused on applied econometric studies, and the use of endogenous growth models represents an innovation in Brazil. These models allow us to capture the externalities of the health sector, as well as its influence on the accumulation of human capital and output.

4. Model

4.1. Longevity

The model is based on van Zon and Muysken (2001). The population is divided into two parts: young people who work in the production of output, health services, and human capital formation, and old people who consume output and health services. People live up to age T , and are active in production up to age A . It is assumed that in every period, n people are born living t years, with health g and human capital h . By hypothesis, longevity T is proportional to the average health level g of the population. Therefore

$$T = \mu \cdot g \quad (1)$$

where μ is a constant. Inactive people are equal to $(T - A) \cdot n$, and an increase in longevity will increase the number of inactive people in the economy, increasing the consumption of health services. In the steady state, the population remains constant, that is, the number of births per period equals the number of deaths.

The utility function considers the link between health, longevity, and total population size:

$$U = \int_0^{\infty} e^{-\rho\tau} (g^\gamma (\frac{C}{L})^{1-\gamma})^{1-\theta} \frac{L}{(1-\theta)} d\tau \quad 0 < \theta < 1 \quad (2)$$

where ρ is the discount rate and $1/\theta$ the intertemporal substitution elasticity; $0 \leq \gamma \leq 1$ measures the relative contribution of health to utility. C is total private consumption, whereas $L = n \cdot T$ is the size of the population. Note, therefore, that longevity is an implicit argument of the utility function, which contributes positively to the households' welfare. The total effective labor supply, which considers the level of human capital and the quality of health, is therefore $h \cdot g \cdot n \cdot A$.

4.2. Production of health services

To integrate health and growth in the context of endogenous growth, productivity is considered to increase due to human capital accumulation and decreasing returns. It is assumed that the production of health services is performed by medical specializations so that a fraction v_i of effective work is employed in the production of knowledge of medical specialization i . It is assumed that the number of medical specializations is proportional to the size of human capital, $\Omega = \pi \cdot h$. Thus, the average increase in the level of health quality is given by:

$$\frac{dg}{dt} = \int_0^{h\pi} \psi (hg v_i \frac{nA}{nT})^\beta \cdot di = \psi \cdot \pi \cdot h \cdot (\frac{hg v A}{\pi h \mu g})^\beta = \psi \cdot (\frac{A}{\mu})^\beta \cdot \pi^{1-\beta} \cdot h \cdot v^\beta \quad (3)$$

ψ is the productivity parameter and v the fraction of the total effective labor supply employed in the health sector. Further, the inequality $0 < \beta \leq 1$ ensures the existence of decreasing returns in the production of health services.

The increase in the general level of health and medical specializations also has costs. The more specialties, the greater the demand for medical care, which includes an increase in visits to doctors and a growing number of lab exams. These lead to a reduction in the number of jobs due to technological developments. It is assumed that this loss is proportional to the number of specializations by a factor ζ :

$$\frac{dg}{dt} = \left[\psi \cdot (\frac{A}{\mu})^\beta \cdot \pi^{1-\beta} \cdot v^\beta - \zeta \cdot \pi \cdot g \right] \cdot h \quad (4)$$

It is then possible to obtain the steady-state health quality level:

$$g^* = \frac{\psi}{\zeta} \cdot (\frac{A}{\pi \cdot \mu})^\beta \cdot v^\beta = z_0 \cdot v^\beta \quad (5)$$

where $z_0 = \frac{\psi}{\zeta} \cdot (\frac{A}{\pi \cdot \mu})^\beta$. Note that the more work assigned to production in the health sector, the higher the quality of health.

4.3. Output and human capital accumulation

The production function can be represented by a Cobb-Douglas function:

$$Y = B \cdot [(1 - u - v) \cdot h \cdot g \cdot n \cdot A]^\alpha \cdot K^{1-\alpha} \quad (6)$$

where Y represents output, K is the capital stock, and B is a constant productivity parameter. The fraction $(1-u-v)$ of the labor supply is used in the output, and the remaining fractions u and v are used on human capital accumulation and production of health services, respectively.

The process of human capital accumulation considers the health of the population:

$$\frac{dh}{dt} = \delta \cdot u \cdot g \cdot h \tag{7}$$

where δ is the productivity parameter. Finally, the accumulation of physical capital is given by:

$$\frac{dK}{dt} = Y - C \tag{8}$$

4.4. Model solution

To fit the model, Social Planner should maximize intertemporal utility (2) with respect to c , u , and v , subject to conditions (6), (7), (8) and (4).

Therefore, after obtaining the first-order conditions, the steady-state solution of the model must satisfy the following simultaneous equations:

$$v = \frac{c^2 - \alpha c + \alpha(1 - \alpha)(1 - \theta)(1 - \gamma)/(\theta + (1 - \theta)2\gamma)}{c^2 - \alpha c + (\frac{1 + \beta}{\beta})\alpha(1 - \alpha)(1 - \theta)(1 - \gamma)/(\theta + (1 - \theta)2\gamma)} \tag{9}$$

$$c = 1 - \frac{(1 - \alpha) \cdot r}{(\theta + \gamma(1 - \theta)) \cdot r + \rho} \tag{10}$$

$$r = \frac{\delta(1 - v)z_0v^\beta - \rho}{\theta + \gamma(1 - \theta)} = \frac{\delta g^*(1 - v) - \rho}{\theta + \gamma(1 - \theta)} \tag{11}$$

$$u = \frac{1 - c}{1 - \alpha}(1 - v) \tag{12}$$

where c is the average propensity to consume and r is the balanced growth rate of the economy.

5. Calibration

For calibrating the model, most information is taken from Instituto Brasileiro de Geografia e Estatística's (IBGE) National Accounts 2014. The estimated population for each municipality in the country is also taken from IBGE (2014), and some parameters were acquired from the literature. For coherence, all the data used in the present study are from 2014, because that is the most recent National Accounts data. The number of physicians in each municipality was acquired from Cnes Data SUS 2014, because of the 2010 Census, but they contain many missing values for the number of physicians. That is because in the Cnes database some physicians are registered in more than one municipality, which may receive funds from the government for these physicians to attend to the people. However, many of these physicians do not show up for work at the appropriate time, and in some hospitals, they even never see patients, although they should.

As mentioned above, the Census does not have a representative number of physicians because there are too many missing values. A very high number of municipalities do not have any physicians, especially the ones with low estimated populations and with low-wage families. The number of physicians from the Cnes SUS database is practically the same to that in the Federal Council of Medicine in Brazil, approximately 350 thousand Brazil-based physicians, which ensures that Cnes SUS is a reliable database. The data from Census IBGE were analyzed in detail for every Brazilian

state in a separate dataset. The estimated population of each municipality was combined with the number of physicians in the Cnes SUS data set for the respective municipality.

For the calibration, the endogenous variable “ v ” has a fixed value and represents the number of physicians divided by 100,000 inhabitants; this is different from the “ v ” used in the Zon and Muysken (2001), because in their study the “ v ” variable represented the total number of workers in the health sector divided by all workers in all sectors. The reason for this is that in the present study, I intend to investigate how the economy reacts when allocating a higher or lower number of physicians per inhabitant to different municipalities in each region. We divide municipalities into those with estimated population above fifty thousand inhabitants and those with an estimated population below fifty thousand. In both cases, the calibration is done for the municipalities in the South and Southeast regions together; the North and Northeast regions are also investigated together. The fifty thousand inhabitants cut off is a good measure because according to IBGE, approximately 90% of Brazilian municipalities have a population below 50 thousand inhabitants.

The Center region of Brazil has not been evaluated because we are interested in comparing the less developed regions of Brazil, North and Northeast, to the more developed regions, South and Southeast.

For the simulation, “ v ” is replaced by the number of physicians of the whole country divided by 100,000 inhabitants. The same steps are performed throughout all the four calibrations and four simulations. Thus, the first calibration studies how the fixed value of physicians' number per inhabitant in municipalities of more than fifty thousand inhabitants in the South and Southeast regions affect economic growth.

Then, for the simulation, the number of physicians in the country per 100,000 inhabitants is substituted for the former “ v ” value to observe how the economic variables react. The second calibration is done with the same region but for municipalities with a population below fifty thousand. The third calibration is done for the municipalities within the North and Northeast regions with inhabitants above fifty thousand, and the fourth calibration, for the same region but for municipalities with below fifty thousand inhabitants. In all simulations, the same “ v ” value is replaced by the old value of v , which is the national value for the number of physicians per 100,000 inhabitants.

The average propensity of consumption, c , was calculated using the consumption/GDP ratio obtained from the National Accounts: $c = 0.6152$. The balanced growth rate, r , was calculated from the last 20 years' average GDP growth rate, $r = 3.055\%$. The discount rate was estimated as $\rho = 0.019$. This value comes from the equation, $\rho = -\log(1/(1+R))$, in which R is the real interest rate calculated by the difference between the accumulated Brazilian national interest rate (Selic) in 2014, 10.96%, and IPCA (inflation) in 2014, 6.40% (BACEN, 2014), that is, $10.96\% - 6.40\% = 4.56\%$. With $R = 4.56\%$, substituting into the equation for ρ , $\rho = 0.019$.

The proportion of capital income in the output was also obtained from the National Accounts of 2014, $\alpha = 0.33$; additionally, as an assumption, we have $\beta = \alpha = 0.33$. With this information, we can calculate the relative contribution of health to utility, γ , and the inverse elasticity of substitution θ through equations (9) and (10) simultaneously, which gives the values of $\gamma = 0.89$ and $\theta = 2.089$. From equation (11), it is possible to calculate the level of health quality at steady state, $g^* = 0.5333$, assuming that the productivity parameter, δ , is equal to 0.1. Using the equation $g^* = z_0 \cdot v^\beta$, results in $z_0 = 3.848$. Finally, from equation (12), it is possible to obtain the participation of effective labor in the production of human capital, $u = 0.5729$. The same steps are repeated to investigate the North and Northeast regions.

6. Results

To estimate the impact of the change in the number of physicians per 100,000 inhabitants, represented by v , the new v , $v = 0.0211$, which is the total number of physicians in the country per 100,000 inhabitants, is substituted back into the equations in place of the old v , $v = 0.0317$, which represented the number of physicians per 100,000 inhabitants into municipalities with a population above 50 thousand. The same is done later, for the North and Northeast regions together.

The four equilibrium equations—(9) to (12)—are solved simultaneously with the results in the Table 1.

Table 1 shows the results for the municipalities with a population above 50 thousand from the Southeast and South regions of Brazil. The cities in these regions are populous, and the number of physicians is also high. Thus, the number of physicians per 100,000 inhabitants is higher compared to the national number. As a result, when the fixed value of ν , from the final steady state, representing the national number, is substituted for the first value of ν , it is implied that the new value of ν is less than the previous one. Therefore, as the value of ν decreases, the balanced growth rate decreases, as expected. The level of health quality decreases because now there are fewer physicians than before. The inverse relation between the average propensity to consume and the number of physicians per 100,000 inhabitants is also noticeable, with ν decreasing and c increasing.

Table 1 - Municipalities with a population above 50 thousand, South and Southeast Regions

| Variable | Initial Steady State | Final Steady State |
|---|----------------------|--------------------|
| Balanced growth rate (r) | 3.05% | 2.49% |
| Level of health quality (g^*) | 53.32% | 46.95% |
| Participation of effective labor in the production of human capital (u) | 57.29% | 53.04% |
| Number of physicians per 100,000 inhabitants (ν) | 0.0317 | 0.0211 |
| Average propensity to consume (c) | 61.52% | 68.22% |

Source: Author's calculations.

Table 2 - Municipalities with a population below 50 thousand, South and Southeast Regions

| Variable | Initial Steady State | Final Steady State |
|---|----------------------|--------------------|
| Balanced growth rate (r) | 3.05% | 4.12% |
| Level of health quality (g^*) | 53.24% | 65.19% |
| Participation of effective labor in the production of human capital (u) | 57.38% | 63.15% |
| Number of physicians per 100,000 inhabitants (ν) | 0.0114 | 0.0211 |
| Average propensity to consume (c) | 61.52% | 52.00% |

Source: Author's calculations.

The same regions are studied in Table 2. The municipalities analyzed have a population below 50 thousand, which explains why the value of ν increased. As a result, the balanced growth rate also increased, and so did the level of health quality, since there are more physicians to attend to the population. When ν increases, the average propensity to consume decreases, as observed. Additionally, the participation of effective labor in the production of human capital also increases.

Table 3 - Municipalities with a population above 50 thousand, North and Northeast Regions

| Variable | Initial Steady State | Final Steady State |
|---|----------------------|--------------------|
| Balanced growth rate (r) | 3.05% | 3.23% |
| Level of health quality (g^*) | 53.28% | 55.30% |
| Participation of effective labor in the production of human capital (u) | 57.34% | 58.50% |
| Number of physicians per 100,000 inhabitants (ν) | 0.0188 | 0.0211 |
| Average propensity to consume (c) | 61.52% | 59.65% |

Source: Author's elaboration.

As regards Table 3, the municipalities with a population above 50 thousand, in the North and Northeast regions present a number of physicians per 100,000 inhabitants still less than the national average. Because v increases the balanced growth rate, r increases. It is intuitive that now, with more physicians, the level of health quality increases, as shown in Table 3. Further, the average propensity to consume decreases. The participation of effective labor in the production of human capital increases by a little.

Table 4 - Municipalities with a population below 50 thousand, North and Northeast Regions

| Variable | Initial Steady State | Final Steady State |
|---|----------------------|--------------------|
| Balanced growth rate (r) | 3.05% | 5.46% |
| Level of health quality (g^*) | 53.33% | 80.20% |
| Participation of effective labor in the production of human capital (u) | 57.29% | 68.03% |
| Number of physicians per 100,000 inhabitants (v) | 0.0061 | 0.0211 |
| Average propensity to consume (c) | 61.52% | 43.91% |

Source: Author's calculations.

Finally, Table 4 analyzes the last situation, municipalities with a population below 50 thousand located in the North and Northeast regions. In this case, the variation in the transition from the initial to the final steady state is the highest compared to the other situations. Part of this is because physicians are in the North and Northeast for municipalities with a population below 50 thousand. Thus, in the simulation, the value of v , the level of health quality, and also the balanced growth increases, whereas propensity to consume decreases. The participation of effective labor in the production of human capital increases.

Table 5 – Consolidated results

| Variable | South and Southeast | | | | North and Northeast | | | |
|---|----------------------------|-------------|----------------------------|-------------|----------------------------|-------------|----------------------------|-------------|
| | Municip. Pop. Below 50,000 | | Municip. Pop. Above 50,000 | | Municip. Pop. Below 50,000 | | Municip. Pop. Above 50,000 | |
| | Initial S. S. | Final S. S. | Initial S. S. | Final S. S. | Initial S. S. | Final S. S. | Initial S. S. | Final S. S. |
| Balanced growth rate (r) | 3.05% | 4.12% | 3.05% | 2.49% | 3.05% | 5.46% | 3.05% | 3.23% |
| Level of health quality (g^*) | 53.24% | 65.19% | 53.32% | 46.95% | 53.33% | 80.20% | 53.28% | 55.30% |
| Participation of effective labor in the production of human capital (u) | 57.38% | 63.15% | 57.29% | 53.04% | 57.29% | 68.03% | 57.34% | 58.50% |
| Number of physicians per 100,000 inhabitants (v) | 0.0114 | 0.0211 | 0.0317 | 0.0211 | 0.0061 | 0.0211 | 0.0188 | 0.0211 |
| Average propensity to consume (c) | 61.52% | 52.00% | 61.52% | 68.22% | 61.52% | 43.91% | 61.52% | 59.65% |

Source: Author's calculations.

In general, the model predicts that increasing the number of physicians per 100,000 inhabitants raises the economy's long-term growth rate, improves the average quality of health, and increases the share of effective labor in the production of human capital. On the other hand, it reduces the participation of effective labor employed in the production of health services and the propensity to consume.

The mechanisms behind these results are as follows: The increase in the number of physicians in a municipality increases the productivity of the health sector. The hypothesis is that with more effective work the sector becomes more productive. On the other hand, the amount of effective work allocated to the health sector decreases due to increased productivity. The net effect is an increase in the general level of health, g^* , and a reduction in the fraction of effective labor used in the production of health services, v .

The expansion of the average level of health positively affects the production of human capital, per equation (7). Workers of better overall health will be able to become more productive. The result is an increase in the rate of accumulation of human capital. The increase in this rate raises the demand for effective labor in this sector. In this way, a larger fraction of the effective labor is used to produce human capital, that is, u increases.

On the demand side, the average propensity to consume, c , tends to decrease. This is because the increased productivity of the health services sector and the human capital accumulation sector make an investment in both sectors more interesting, shifting resources from consumption to investment. It is important to realize that there will be no decrease in consumption since the output will grow faster, but consumption will represent a slightly lower percentage of GDP.

In summary, the increase in the number of physicians improves the level of workers' health with a positive impact on the accumulation of human capital and on investment in physical capital, which allows for an increase in the growth rate of the economy.

7. Conclusions

This study used the model of Zon and Muysken (2001) to investigate the effect of increasing or decreasing the value of v in different regions, the number of physicians divided by its respective municipality, on the production of health services, the accumulation of human capital, and economic growth in Brazil. All three sectors are interrelated, since the overall level of health affects workers and the accumulation of human capital, whereas a higher level of human capital is related to better quality of health. Finally, health and human capital affect the output of the economy.

The results appear to be positive from the viewpoint of economic growth. In general, the model predicts that an increase in the number of physicians favors economic growth by raising the level of workers' health, which is associated with an increase in human and physical capital. Human capital grows through the increase in the number of workers in the production of human capital, whereas the investment in physical capital grows through the reduction of the average propensity to consume.

Brazil's health spending as a proportion of GDP is comparable to those of rich OECD countries. However, investment in the public sector is relatively small, accounting for less than half of the expenditure, whereas in developed countries almost $\frac{3}{4}$ of the total expenditure is disbursed to the public sector. In fact, these figures indicate the low quality of Brazilian public health, a result of low investment and the population's efforts to pay for private plans to have better care. What this analysis suggests is that a more pronounced effort for public sector investment in health can help the Brazilian economy to increase its rate of growth. The federal government could allocate the physicians of different municipalities throughout all the states in the country to make the number of physicians per inhabitant more homogenous. Increasing the number of physicians in municipalities that need them the most would influence economic growth.

The decentralization of physicians from denser municipalities to smaller ones positively impacts the health and wellbeing of the population overall. It is necessary to formulate a public policy that allocates the physicians within the country more efficiently; the suggested proposal is federal public tender for physicians. The public contest would allocate the physicians in a better way; as a result, the number of physicians per inhabitant would increase in municipalities with greater need for these professionals. Therefore, decentralizing the physicians would better attend to the population, especially the poor who live in municipalities with few inhabitants and with almost no physicians.

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