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Article

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The replacement of payroll tax by a tax on revenues: A study of sectorial impacts on the Brazilian economy

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Abstract

A topic of current research in discussion about the Brazilian economy is the exemption from payroll taxes, which aims to stimulate competitiveness of the firms, boosting economic growth. This topic was introduced in Brazil by new laws that proposed replacing the payroll tax with a new tax on revenues. The payroll tax rate of 20% was replaced by a tax rate of 1% or 2% on revenue. This change has been applied primarily in labor-intensive economic sectors. In this paper, a neoclassical model was used to evaluate some sectorial impacts of these tax changes. The results show positive effects of this reform, among them, the increase in aggregate consumption and capital stock. Employment also grows in the labor-intensive sector. However, under a government revenue neutral scenario, these effects are almost completely lost, which shows some evidence about the low efficiency of these reforms.

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Resumo

Um tema em recente no âmbito da economia brasileira é a desoneração da folha de pagamentos, a qual objetiva estimular a competitividade das firmas, em direção ao crescimento econômico. Este tópico foi introduzido no Brasil por meio de medidas provisórias as quais propunham substituir a alíquota previdenciária patronal incidente sobre a folha de pagamentos por uma nova alíquota incidente sobre o faturamento. A alíquota patronal de 20% foi substituída por uma alíquota de 1% ou 2% sobre o faturamento. Esta mudança sendo feita primeiramente em setores econômicos intensivos em mão de obra. Neste artigo, um modelo neoclássico foi utilizado para avaliar alguns impactos setoriais advindos dessas mudanças. Os resultados evidenciam efeitos positivos dessa reforma, entre eles, crescimento do consumo agregado, e estoque de capital. O emprego também cresce no setor intensivo em

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trabalho. Entretanto, sob um cenário neutro de arrecadação, esses efeitos são praticamente nulos, o que mostra alguma evidência acerca da baixa eficiência dessas reformas.

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Palavras chave: Modelos neoclássicos; Reformas tributárias; Desoneração da folha de pagamentos

1. Introduction

In August 2011 the Brazilian government proposed a set of programs and economic actions to seek productivity growth and competitiveness of the economy.¹ One of the first measures was a tax modification that replaced the payroll tax of labor-intensive firms by a tax on their revenues. The payroll tax rate of 20% was replaced by a tax rate of 1% or 2% of revenues of the benefited sectors. By the beginning of 2014, this measure has already included 56 sectors of the Brazilian economy².

The rate of 1% applies on revenues of industrial sectors, whereas for services³ the tax rate is 2%. This change was not revenue neutral. In fact, the Secretariat of Federal Revenue of Brazil (RFB) estimates the revenue loss at 0.02% of GDP.

In this paper we carried out some simulations to study the macroeconomic effects of this tax reform. We built a neoclassical model with a representative household, two intermediate firms – one labor-intensive and other capital-intensive – and a unique final good firm. Four scenarios were considered in the analysis: the first reform (referred to **reform 1**) replaces the payroll tax rate by a tax rate of 1% on revenue of the labor-intensive firm; the second reform (**reform 2**) considers a tax rate of 2% on revenue of the labor-intensive firms; the third simulation (**reform 3**) replaces the payroll tax rate by a tax (on revenue) which is government revenue neutral, and finally, the fourth tax change (**reform 4**) uses a payroll tax rate which implies the same level of government revenues losses of the first reform in the long term. Our model was based in Paes (2011, 2012).

The rest of this paper proceeds as follows. In Section 2, we review the applied literature, while in Section 3, we describe the macroeconomic model used in this study. Section 4 contains the description of the model calibration and in Section 5, we discuss the results. Finally, in Section 6 we present the conclusions of this research.

2. A review of literature

There are many works that analyze the economic effects associated with tax changes. Studies based on dynamic general equilibrium models have been quite prevalent. As an initial reference, Fullerton (1982) used a neoclassical model to study the impacts of several tax reforms on the U.S. economy. Auerbach and Kotlikoff (1987) constructed an overlapping generation (OLG) model to analyze how changes in fiscal policies affect the American economy. In this paper, the authors evaluated some economic impacts of changes in the tax rates on income, wages, and consumption.

Lucas (1990) studied the impacts of shifting capital income taxation to labor income taxation. Following a neoclassical perspective, Cooley and Hansen (1992) analyzed the economic effects of some tax changes that combine different rates for capital and labor income taxes. The results suggest that the welfare costs are strictly lower in economies that replace taxation on capital by other less distortive taxes such as consumption taxes.

Prescott (2002) looks at the tax burden and the trade-off between consumption and leisure. In his study, he compares the productivity per worker in the USA and France, concluding that the differences between consumption taxes and labor taxes have a big impact on productivity per worker in these countries.

¹ MIDC (Ministério do Desenvolvimento and Indústria e Comércio Exterior, 2011).

² For example, auto parts, poultry, machinery and equipment, toys, call center, ceramics, retail trade, manufacturing, construction, footwear, design house, railway equipment, medical and dental equipment, aircraft, ships, buses, pharmacies and medicines, stoves, hotels, optical instruments, electrical equipment, furniture, pulp and paper, stones and ornamental rocks, plastic, tires, textiles, and information technology.

³ Computer services, call center, design houses, hotels, public road transport, construction of infrastructure, maintenance of machinery and equipment, support services to the defense industry, engineering and architecture, technical support in computer.

Using data of the World War II, McGrattan (McGrattan and Ohanian, 2008) examined the predictive power of neoclassical models to study the economic effects of fiscal shocks. Their model was able to estimate real GDP, investment, consumption, labor supply, capital and labor income, close to the empirical values of the World War II period.

A pioneering study applied to the Brazilian economy was proposed by Araújo and Ferreira (1999). They analyzed the economic effects of the fiscal policy changes that were discussed in Brazil between 1995 and 1997. They focused on a tax change that reduced taxes on labor and capital, while increasing the taxation on consumption. The results show an increase of product, employment, capital stock and household welfare.

Paes and Bugarin (2006) analyzed the economic effects of two tax reforms on the Brazilian economy. In the first tax change, the authors proposed the end of the cumulativeness of PIS/COFINS⁴ and the transfer of half of the employer payroll tax to a new contribution on value added. In the second tax change, the social contribution on added value (CSVA) was suggested, replacing the ICMS,⁵ as well as a new excise tax replacing the IPI⁶. In the long term, the reforms led to the increase of output, consumption, employment, capital stock, and welfare, but when the transition periods were considered, these gains were reduced significantly.

Following a neoclassical approach, Cavalcanti (2008) analyzed the allocative and welfare impacts of a tax change that replaces payroll taxes by a tax on the firms' revenues. The results implied negative effects on welfare and capital stock, with an increase of employment in the long-term. Bitencourt and Teixeira (2008) proposed a multi sectoral model to simulate competitiveness impacts arising from payroll and labor taxes cuts. The results show a small decline on wages, increase in capital stock, investments and exports, favoring the domestic market.

Paes (2011) constructed a neoclassical model with 55 firms to simulate the economic effects of substituting all consumption taxes in Brazil by a value-added tax, with only one exemption to essential goods. The results indicated a slight expansion in the output, consumption, employment and investment, with small loss in government revenue and also with welfare's growth. In addition, industrial sectors have benefited in expense of the services sector. The author also estimated the effects of replacing the payroll tax only to industrial sector by an 20% elevation in COFINS for all sectors (Paes, 2012). The results lead to a massive growth in employment and industrial products, with a small decline in agriculture and services.

This paper provides a new research approach for the Brazilian economic literature on the impacts of tax changes in payroll taxes by introducing two types of firms: labor-intensive and capital-intensive. Only the first has its payroll tax replaced by a revenue tax, while the second has not tax changes. In this sense, we have proposed a modified version of the model used by Paes (2011, 2012).

3. The macroeconomic model

The economy is based on a deterministic neoclassical model with capital accumulation and discrete time. This artificial economy is closed, with constant-scale returns and no population growth. The households are aggregated by a representative agent with utility function depending on their consumption and leisure levels. The representative household offers labor and rents capital to the intermediate firms. The levels of consumption and leisure are chosen in order to maximize the discounted utility restricted by the budget constraint of the representative household.

In the intermediate sector there are two competitive firms, one labor-intensive, and another capital-intensive. The final good of the economy is produced by a convex combination of the intermediate goods. The government revenue come from taxes on consumption, capital income, labor income, and on revenues and payroll of the intermediate firms. The taxes on consumption, capital and labor are paid by the representative household, and the taxes on revenues and payroll are paid by the intermediate firms.

⁴ The PIS is a consumption tax used in order to finance the payment of unemployment insurance and to subsidize the workers who earn up to two minimum wages. COFINS is also a consumption tax to finance social security.

⁵ In Brazil, the ICMS is the main tax on consumption of goods and services.

⁶ The IPI is an excise tax on consumption of manufactured products.

3.1. Representative household

The representative household has an infinite life and maximizes its discounted fluxes of logarithmic utilities subject to budget constraint. The problem of the representative household is described below

$$\max_{\{c_t, l_t, h_t, k_t\}} \sum_{t \geq 0} \beta^t [\log(c_t) + \alpha \log(l_t)],$$

subject to restrictions

$$P_t[(1 + \tau_{ct})c_t + k_{t+1} - (1 - \delta)k_t] = (1 - \tau_{ht})w_t h_t + (1 - \tau_{kt})r_t k_t + P_t T_t$$

$$h_t + l_t = 1,$$

where β is the intertemporal discount factor and α is the relative weight of leisure in the utility function; c_t , h_t , l_t e k_t are the consumption, labor hours, leisure hours, and capital stock at period- t , respectively; r_t and w_t are the capital rent price and the wage paid by intermediate firms at period- t , respectively; P_t is the price of the final good at period- t ; T_t is a lump-sum transfer made by the government to the representative household at period- t . The tax rates on consumption, labor income and capital returns are represented by τ_{ct} , τ_{ht} , τ_{kt} , respectively. In order to avoid labor and capital allocations in only one sector we have assumed that both firms (labor-intensive and capital-intensive) pay the same rentals r_t and wages w_t .

The Lagrangian of the maximization problem above is (Ljungqvist and Sargent, 2004)

$$\begin{aligned} L = & \beta^t [\log(c_t) + \alpha \log(1 - h_t)] + \beta^{t+1} [\log(c_{t+1})\alpha \log(1 - h_{t+1})] + (\beta^t \lambda_t) \\ & \times [P_t(1 + \tau_{ct})c_t + k_{t+1} - (1 - \delta)k_t - (1 - \tau_{ht})w_t h_t - (1 - \tau_{kt})r_t k_t - P_t T_t] \\ & + \beta^{t+1} \lambda_{t+1} [P_{t+1}(1 + \tau_{ct+1})c_{t+1} + k_{t+2} - (1 - \delta)k_{t+1}] - (\beta^{t+1} \lambda_{t+1}) \\ & \times [(1 - \tau_{ht+1})w_{t+1} h_{t+1} + (1 - \tau_{kt+1})r_{t+1} k_{t+1} + P_{t+1} T_{t+1}]. \end{aligned}$$

Considering the Lagrange multiplier, $\beta^t \lambda_t$, at time- t , the first-order conditions are given by

$$\frac{\partial L}{\partial c_t} = 0 \Leftrightarrow \beta^t \frac{1}{c_t} + \beta^t \lambda_t P_t (1 + \tau_{ct}) = 0 \Leftrightarrow \lambda_t = -\frac{1}{P_t (1 + \tau_{ct}) c_t},$$

$$\frac{\partial L}{\partial h_t} = 0 \Leftrightarrow -\frac{\alpha}{1 - h_t} - \lambda_t (1 - \tau_{ht}) w_t = 0,$$

$$\frac{\partial L}{\partial k_{t+1}} = 0 \Leftrightarrow \beta^t \lambda_t - \beta^{t+1} \lambda_{t+1} (1 - \delta) - \beta^{t+1} \lambda_{t+1} (1 - \tau_{kt+1}) r_{t+1} = 0.$$

After some algebraic manipulation which includes to substitute λ_t and λ_{t+1} obtained by (4) into Eqs. (5) and (6), we obtain the following relationships

$$h_t = 1 - \frac{\alpha P_t (1 + \tau_{ct}) c_t}{(1 - \tau_{ht}) w_t},$$

$$c_{t+1} = \beta \left(\frac{1 + \tau_{ct}}{1 + \tau_{ct+1}} \right) [(1 - \tau_{kt+1}) r_{t+1} + (1 - \delta)] c_t.$$

Eq. (7) describes the trade-off between consumption and labor, while Eq. (8) is the Euler's equation (see, e.g., Barro and Sala-I-Martin, 1995), which describes the trade-off between present and future consumption.

3.2. Intermediate firms

We suppose that in the production of intermediate goods there are two competitive firms, one labor-intensive (sector I), and another capital-intensive (sector \tilde{I}). The intermediate firms rent capital and labor from households to

produce goods and services for the economy. The production functions of the intermediate firms follow a Cobb–Douglas structure as described below:

$$Y_{st} = A_s \hat{k}_{st}^{\theta_s} \hat{h}_{st}^{1-\theta_s}, \quad (9)$$

where Y_{st} , \hat{k}_{st} , \hat{h}_{st} are, respectively, the product, capital and labor factors of the sector $s \in \{I, \tilde{I}\}$ at period- t ; θ_s is the share of capital income in the product of the sector s . The constant A_s denotes the technology of this sector.

The problem of an intermediary firm s is given by the choice of the demands for labor hours and capital stock in order to maximize its profit. In general, at time- t , the aggregate profit of the sector s is given by

$$\pi_{st} = (1 - \tau_{ft}^s) p_{st} Y_{st} - (1 + \tau_{pt}^s) w_{st} \hat{h}_{st} - r_{st} \hat{k}_{st}, \quad (10)$$

where π_{st} indicates the profit of the firm $s \in \{I, \tilde{I}\}$ at time- t ; \hat{h}_{st} and \hat{k}_{st} are the labor and capital demands of the firm s at time- t ; τ_{ft}^s e τ_{pt}^s are the tax rates on revenue and payroll paid by the firm s at period- t ; the quantities r_{st} and w_{st} denote, respectively, the capital rental price and the wage paid by the firm s at period- t ; p_{st} is the price of the intermediate good produced by sector s .

In the model, we have considered the tax rates on revenues for the first steady state of the economy (τ_{f0}^s , $s \in \{I, \tilde{I}\}$, respectively) equal to zero. Furthermore, at initial steady state, we made $\tau_{p0}^I = \tau_{p0}^{\tilde{I}} = \tau_p$, with τ_p being calibrated using data from Brazilian national accounts from 2009. In later periods, for the scenarios 1, 2 and 3, the payroll tax rates of the labor-intensive sector, τ_{pt}^I , are equal to zero and its tax rates on revenues are chosen according each analyzed reform, namely, $\tau_{ft}^I = 1\%$, 2% or 4.7% for the reforms 1, 2 and 3, respectively. For the simulation 4, the payroll tax rate of the labor-intensive sector is reduced in order to maintain the same magnitude of government revenues losses of the first reform.

At period- t , the *first order conditions* of the optimization problems of intermediate firms are obtained equalling to zero the marginal profits vector (i.e., $(\frac{\partial \pi_{st}}{\partial \hat{k}_{st}}, \frac{\partial \pi_{st}}{\partial \hat{h}_{st}}) = (0, 0)$), for which the solutions are

$$r_{st} = p_{st} (1 - \tau_{ft}^s) \theta_s A_s \hat{k}_{st}^{\theta_s - 1} \hat{h}_{st}^{1-\theta_s}, \quad (11)$$

$$w_{st} = \frac{p_{st} (1 - \tau_{ft}^s) (1 - \theta_s) A_s \hat{k}_{st}^{\theta_s} \hat{h}_{st}^{-\theta_s}}{(1 + \tau_{pt}^s)}. \quad (12)$$

3.3. The final good firm

Here, we suppose that the final good firm is competitive and its product can be computed by combining intermediate goods using a *constant elasticity of substitution* (CES) production function as

$$Y_t = \left[Y_{It}^{1/\lambda} + Y_{\tilde{I}t}^{1/\lambda} \right]^\lambda, \quad (13)$$

where $1 < \lambda < \infty$ is the substitution elasticity parameter between intermediate inputs. The functional form described above is widely used in macroeconomic literature. Furthermore, it has a Gorman's type form, which ensures the existence of the steady state conditions (see, e.g, [Acemoglu, 2009](#)). Denoting by σ the substitution elasticity between intermediate goods, it follows that $\sigma = \frac{\lambda}{\lambda-1}$. Then, when $\lambda \rightarrow 1^+$ the goods tend to be perfectly substitutes and when $\lambda \rightarrow \infty$, the goods tend to be perfectly complementary.

The maximization of the profit,

$$\Pi_t = P_t Y_t - p_{It} Y_{It} - p_{\tilde{I}t} Y_{\tilde{I}t}, \quad (14)$$

results in the following *first order conditions*:

$$\left(\frac{p_{It}}{P_t} \right)^{\frac{\lambda}{1-\lambda}} = \frac{Y_{It}}{Y_t}, \quad (15)$$

$$\left(\frac{p_{\tilde{I}t}}{P_t} \right)^{\frac{\lambda}{1-\lambda}} = \frac{Y_{\tilde{I}t}}{Y_t}. \quad (16)$$

Eq. (14), (15), and (16) imply the following relationship between the prices of intermediate and final goods:

$$P_t = \left[p_{It}^{1/(1-\lambda)} + p_{\tilde{I}t}^{1/(1-\lambda)} \right]^{1-\lambda}. \quad (17)$$

In order to simplify the characterization of the relative prices we have chosen $P_t = 1$ for all period- t .

3.4. Government

The government is passive, i.e., given the choices made by the other agents, it only makes sure that its budget is balanced. In this sense, the government uses the tax revenues to finance public spending and transfers to households. The government restriction at period- t is

$$G + T_t = \tau_{ct} c_t + \tau_{kt} r_t k_t + \tau_{ht} w_t h_t + \tau_{pI}^I w_{It} \hat{h}_{It} + \tau_{p\tilde{I}}^{\tilde{I}} w_{\tilde{I}t} \hat{h}_{\tilde{I}t} + \tau_{fI}^I p_{It} Y_{It} + \tau_{f\tilde{I}}^{\tilde{I}} p_{\tilde{I}t} Y_{\tilde{I}t}, \quad (18)$$

where G is the government spending (constant for all $t = 1, \dots, \mathbf{T}$) and T_t is the government transfers to the representative household at period- t .

3.5. Steady state

In the two steady states (before and after each reform, respectively), the level of variables k , Y and c (capital, GDP and consumption) grow at a zero rate. For the first steady state of the economy, $\tau_p^I = \tau_p^{\tilde{I}} = \tau_p$ and $\tau_f^I = \tau_f^{\tilde{I}} = 0$. At the second stationary equilibrium, on the reforms 1, 2 and 3, $\tau_p^I = 0$, $\tau_p^{\tilde{I}} = \tau_p$, $\tau_f^I = 0$, and the choice of $\tau_f^{\tilde{I}}$ is made in accordance with the analyzed scenario ($\tau_f^{\tilde{I}} = 1\%$, 2% or 4.7% – reforms 1, 2 and 3, respectively). For the fourth reform, $\tau_p^I = 1.3\%$, $\tau_p^{\tilde{I}} = \tau_p$, $\tau_f^I = 0$, and $\tau_f^{\tilde{I}} = 0$. In this section, we described the equations at the first steady state of the economy.

Assuming I^* being the investment at the steady state, it follows that

$$I^* = k_{t^*+1}^* - (1 - \delta) k_{t^*}^*, \quad (19)$$

$$k_{t^*+1}^* = k_{t^*}^*, \quad (20)$$

where t^* is the first steady state period of the economy. Eqs. (19) and (20) imply that $\delta = \frac{I^*}{k_{t^*}^*}$.

Labor hours of the representative household is

$$h_{t^*} = 1 - \frac{\alpha(1 + \tau_{ct^*}) c_{t^*}}{(1 - \tau_{ht^*}) w_{t^*}}. \quad (21)$$

When $c_{t^*+1} = c_{t^*}$, Eq. (8) simplifies to

$$\beta [(1 - \tau_k) r_{t^*} + (1 - \delta)] = 1. \quad (22)$$

Prices of the intermediate goods following the equations

$$V_{A_I}^{t^*} = p_{I t^*} \left[\frac{Y_{I t^*}}{Y_{t^*}} \right], \quad (23)$$

$$V_{A_{\tilde{I}}}^{t^*} = p_{\tilde{I} t^*} \left[\frac{Y_{\tilde{I} t^*}}{Y_{t^*}} \right], \quad (24)$$

where $V_{A_I}^{t^*}$ and $V_{A_{\tilde{I}}}^{t^*}$ are the shares of the products of labor-intensive and capital-intensive sectors in the total output of the economy at period- t^* , respectively.

Capital stocks of the intermediate firms (\hat{k}_{It^*} and $\hat{k}_{\tilde{I}t^*}$) can be computed through the share of the capital income on GDP as

$$r_{t^*} \left[\frac{\hat{k}_{It^*}}{Y_{t^*}} \right] + r_{\tilde{I}t^*} \left[\frac{\hat{k}_{\tilde{I}t^*}}{Y_{t^*}} \right] = p_{I t^*} \theta_I \left[\frac{Y_{I t^*}}{Y_{t^*}} \right] + p_{\tilde{I} t^*} \theta_{\tilde{I}} \left[\frac{Y_{\tilde{I} t^*}}{Y_{t^*}} \right], \quad (25)$$

where $k_t = \hat{k}_t + \hat{k}_{\bar{t}}$ for all t . Moreover, in order to avoid any capital stock (\hat{k}_t or $\hat{k}_{\bar{t}}$) collapses to zero, we assume that $r_t = r_{\bar{t}} = r_t$, for all t .

The computation of wages assumes that both firms pay the same amount ($w_t = w_{\bar{t}} = w_t$), for all t . This assumption was made to avoid households to work only for the sector that pays the highest wage. The expressions involving wages are

$$\left[\frac{w_{I_t^*}}{Y_t^*} \right] \hat{h}_{I_t^*} = \frac{p_{I_t^*} (1 - \theta_I)}{(1 + \tau_p)} \left[\frac{Y_{I_t^*}}{Y_t^*} \right], \quad (26)$$

$$\left[\frac{w_{\bar{I}_t^*}}{Y_t^*} \right] \hat{h}_{\bar{I}_t^*} = \frac{p_{\bar{I}_t^*} (1 - \theta_{\bar{I}})}{(1 + \tau_p)} \left[\frac{Y_{\bar{I}_t^*}}{Y_t^*} \right], \quad (27)$$

where, $h_t = \hat{h}_t + \hat{h}_{\bar{t}}$, for all t . Thus,

$$(1 + \tau_p) \left[\frac{w_t^*}{Y_t^*} \right] h_t = (1 - \theta_I) V_{A_I}^* + (1 - \theta_{\bar{I}}) V_{A_{\bar{I}}}^*. \quad (28)$$

For the calculation of government transfers we used Eq. (18) with $\tau_{pI}^* = \tau_{p\bar{I}}^* = \tau_p$ and $\tau_{fI}^* = \tau_{f\bar{I}}^* = 0$. Finally, the aggregate constraint is given by

$$c_t^* + \delta k_t^* + G_t^* = Y_t^*. \quad (29)$$

3.6. Transitional dynamic

The equilibrium of the dynamic system is given by the solution of the non-linear system involving Eqs. (1), (7), (8), by consider $r_t = r_{\bar{t}}$ and $w_t = w_{\bar{t}}$ using the expressions in (11) and (12), by Eqs. (15), (16), (18), by the aggregate equations $k_t = \hat{k}_t + \hat{k}_{\bar{t}}$ and $h_t = \hat{h}_t + \hat{h}_{\bar{t}}$ for all t , and considering an initial capital stock ($k_0 = k_t^*$) with a transition period of $\mathbf{T} = 200$.

In the equilibrium solution, the trajectories of the variables c_t , h_t , \hat{h}_t , $\hat{h}_{\bar{t}}$, k_t , \hat{k}_t , $\hat{k}_{\bar{t}}$, p_t , $p_{\bar{t}}$, and T_t , $t = 1, \dots, \mathbf{T}$, are obtained using the non-linear optimization algorithm proposed by Broyden (1965) which is a quasi-Newton algorithm that aimed at obtaining the solutions by solving a single non-linear system including all equations of the transition period for each analysed tax reform.

4. Calibration

The data used in the calibration step were extracted from IBGE's (Brazilian Institute of Geography and Statistics) for the years 2008 and 2009. For simplicity, we considered the price of the final product as a numeraire. We classified as labor-intensive firms the economic sectors where the labor compensation is larger than the gross operating surplus. The opposite happens for firms classified as capital-intensive. The calibration of the model is described in the following subsections.

4.1. Consumption, government expenditure and investment

According to data from IBGE, (consumption)/GDP, (investment)/GDP, and (government spending)/GDP ratios were calibrated as 61.02%, 17.81%, and 21.17% respectively. In our analysis, we fix the labor hours at $h = 0.25$ which corresponds to approximately 44 h of work per week ($(44/168) = 0.26$). The return of capital r_t^* was considered equal to the real Brazilian interest rate, which was defined by the difference between the Brazilian nominal interest rate (the SELIC interest rate) and the extended national consumer price index (IPCA). The adjusted real interest rate was $r_t^* = 2.45\%$ per annum at the end of 2009.

Table 1
Tax revenue distribution according to IBGE's National Accounts (2009).

Generator fact	Percentage of GDP
Tax revenues on labor income	9.61
Tax revenues on payroll	3.84
Tax revenues on consumption	14.11
Tax revenues on capital	6.08
Tax burden	33.64

4.2. Capital participations in sector incomes

The shares of capital income in each sector (labor-intensive and capital-intensive), denoted by θ_I and $\theta_{\tilde{I}}$, were obtained by dividing its gross operating surplus by product of the corresponding sector. Using IBGE's data, we found $\theta_I = 0.2930$ and $\theta_{\tilde{I}} = 0.7280$, respectively.

4.3. Taxation

The tax system was divided in five blocks: taxes on labor income, taxes on capital income, taxes on consumption, taxes on revenues, and payroll taxes. In the model, taxes on capital, labor, and consumption are paid by the representative household and the intermediate firms bear the costs of taxation on payroll and revenues.

In the first steady state, both sectors (I and \tilde{I}) are subject to the same payroll taxation and do not pay taxes on revenues. Thus, in the initial steady state, there is no difference in taxation between them. From the transition to the new steady state, the labor-intensive firm replaces his payroll tax rate τ_p^I by a tax rate of 1%, 2% or 4.7% on revenues (reforms 1, 2, and 3, respectively). During this period, the capital-intensive firm (sector \tilde{I}) remains under the same tax regime used in the first steady state. The distribution of tax revenues was calibrated from IBGE's data and is available in [Table 1](#).

The tax rates were calculated based on [Table 1](#). Denoting the (labor tax revenue)/GDP ratio by 'arrtrab' the labor tax rate is calculated by

$$\tau_h = \frac{arrtrab}{w_{I^*} h_{I^*}} = 17.82\%. \quad (30)$$

The payroll tax rate is calculated by dividing the share of the payroll tax on GDP (*arrpatr*) by the total labor income share in the product of the economy:

$$\tau_p = \frac{arrpatr}{w_{I^*} h_{I^*}} = 7.12\%. \quad (31)$$

The tax rate on capital income is obtained by dividing the revenue from the tax on capital income (*arrcap*) by the share of capital income in the output of the economy:

$$\tau_k = \frac{arrcap}{r_{I^*} k_{I^*}} = 14.41\%. \quad (32)$$

4.4. Intermediate goods prices

The prices of the intermediate goods were obtained through Eqs. (23) and (24) considering the value of the constant λ (*elasticity substitution constant*) according to the estimate of [Christiano et al. \(2005\)](#) ($\lambda = 1.85$). Thus, Eqs. (15), (16), (23), and (24) imply $p_{I^*} = 1.3496$ and $p_{\tilde{I}^*} = 2.8045$.

4.5. Capital stock, wages, and labor hours

The aggregate capital stock was computed by Eqs. (11), (23), (24), and (25), and considering $r_{II^*} = r_{\tilde{I}^*} = r_{I^*}$, and $k_{I^*} = \hat{k}_{II^*} + \hat{k}_{\tilde{I}^*}$. Thus, $k_{I^*} = 14.8181$, $\hat{k}_{II^*} = 7.2253$ and $\hat{k}_{\tilde{I}^*} = 7.5928$.

Table 2
Long-term macroeconomic results.

Tax rates discrimination	Reform 1	Reform 2	Reform 3	Reform 4
Tax rate on consumption	14.41%	14.41%	14.41%	14.41%
Tax rate on labor	17.82%	17.82%	17.82%	17.82%
Payroll tax rate	0.00%	0.00%	0.00%	1.300%
Tax rate on capital	23.13%	23.13%	23.13%	23.13%
Tax rate on the labor-intensive revenue	1.00%	2.00%	4.70%	0.00%
Tax rate on the capital-intensive revenue	0.00%	0.00%	0.00%	0.00%
Percentage changes in macroeconomic variables				
Aggregate capital stock	1.5148%	0.3004%	−2.9270%	2.2196%
Labor-intensive capital stock	2.1084%	0.0715%	−5.3194%	3.3737%
Capital-intensive capital stock	0.9500%	0.5182%	−0.6505%	1.1214%
GDP	2.5039%	1.6425%	−0.6793%	2.7262%
Labor-intensive product	3.7115%	2.5216%	−0.6790%	3.9684%
Capital-intensive product	−0.3252%	−0.4222%	−0.6801%	−0.1834%
Consumption	3.6622%	2.6043%	−0.2604%	3.8211%
Investment	1.5148%	0.3004%	−2.9270%	2.2196%
Government spending	0.0000%	0.0000%	0.0000%	0.0000%
Government revenue	−3.4841%	−2.6027%	−0.4038%	−3.4891%
Aggregate labor hours	3.2576%	2.6518%	1.0207%	3.1229%
Labor hours of the labor-intensive sector	4.3833%	3.5846%	1.3103%	4.2159%
Labor hours of the capital-intensive sector	−3.6597%	−2.8963%	−0.7592%	−3.5936%
Welfare	1.0187%	0.6128%	−0.5316%	1.1595%
Present welfare	0.5841%	0.5164%	0.2899%	0.5328%

The wage was calculated by Eqs. (26), (27), and (28), considering $w_{I^*} = w_{\bar{I}^*} = w_{T^*}$. This assumption was made to avoid labor allocations only in the sector which pays the highest wage. Since only the representative household supplies labor for both sectors, there is no reason to have different wages between them. Thus, $w_{T^*} = 2.1572$. The labor hours were calibrated from Eqs. (26) and (27), which result in $\hat{h}_{I^*} = 0.2150$ and $\hat{h}_{\bar{I}^*} = 0.0350$.

4.6. Weight of leisure in the utility function, intertemporal discount rate, depreciation, and sectoral products

The weight of leisure in the utility function of the representative household was obtained by equation (7), which provides $\alpha = 1.7696$. To calibrate the depreciation δ , given the ratios (investment)/GDP, denoted by I^* , and (capital)/GDP, represented by k_{T^*} , Eqs. (19) and (20) provide $\delta = 0.0369$.

The intertemporal discount rate was calculated by Eqs. (22) that implies $\beta = 0.9634$. Using Eqs. (15) and (16), the outputs of the intermediate firms are $Y_{I^*} = 0.5207$ and $Y_{\bar{I}^*} = 0.1060$, respectively.

4.7. Government transfers

We use equation (18) which implies $G = 21.17\%$.

5. Simulation results

The reforms are characterized by the replacement of payroll tax rate of the labor-intensive sector by a tax on its revenue. The first simulation (reform 1) establishes a tax rate of 1% on its revenue, the second simulation (reform 2) proposes a tax rate of 2% on its revenue. The third reform is neutral with respect to government revenue in the first steady state, with a tax rate τ_{ft}^I , $t = 1, \dots, T$, of 4.7%, i.e., $\tau_{p0} w_0 h_{I0} = (4.7\%) p_{I0} Y_{I0}$. In the final simulation, the tax change was made only in the payroll tax of the labor-intensive sector. In this sense, we chose a payroll tax rate that leads to the same fall in government revenue of reform 1, which is less than the level calibrated in Section 4. In all analysis, we fixed the government spending at the level calibrated in Section 4, so that, any fall in government revenues is fully financed with government transfers.

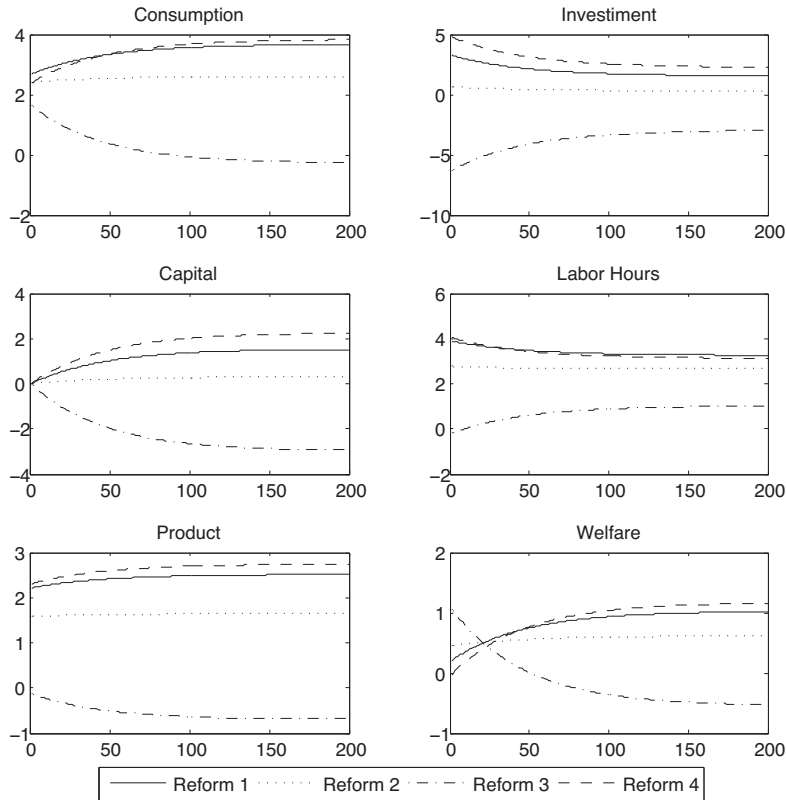


Fig. 1. Results in economic aggregates after each reform. On the y-axes, the percentage changes according to the values of the first steady state. On the x-axes, the time in years after reforms.

The long-term results are showed in [Table 2](#). The values in [Table 2](#) are presented in percentage changes relatively to the first steady state. For each reform, the table shows the new taxes rates (upper lines), the macroeconomic variables changes (center lines) and the welfare results (bottom lines). The welfare variations were computed using the consumption compensating variation as made in [Araújo and Ferreira \(1999\)](#).

In order to computing the welfare variation in present value (at initial period) we used the following methodology: (1) first, we computed the values $\{c_t d_t\}, t = 1, \dots, T$, and $\{Y_t\}, t = 1, \dots, T$, where d_t is the consumption compensating variation at period t , so that, each $\{c_t d_t\}, t = 1, \dots, T$, accounts the consumption variation to keep the representative household with the same utility level of the first period; (2) then, we obtained the present values of the flows $\{c_t d_t\}_{t=1, \dots, T}$ and $\{Y_t\}_{t=1, \dots, T}$ (denoted by $VPcd$ and VPY , respectively), according to the expressions

$$VPcd = \sum_{t=1}^T \frac{c_t d_t}{\prod_{j=1}^t (1 + r_j)}, \tag{33}$$

$$VPY = \sum_{t=1}^T \frac{Y_t}{\prod_{j=1}^t (1 + r_j)}, \tag{34}$$

where r_t is the real interest rate at period- t . Thus, the present value of the welfare variation can be expressed in terms of the GDP by

$$VPwc = \frac{VPcd}{VPY}. \tag{35}$$

[Fig. 1](#) shows the paths of the aggregate variables (consumption, investment, capital stock, labor-hours, and GDP) and also the welfare variation for each reform. In each graphic of [Fig. 1](#), the horizontal axis denotes the transition

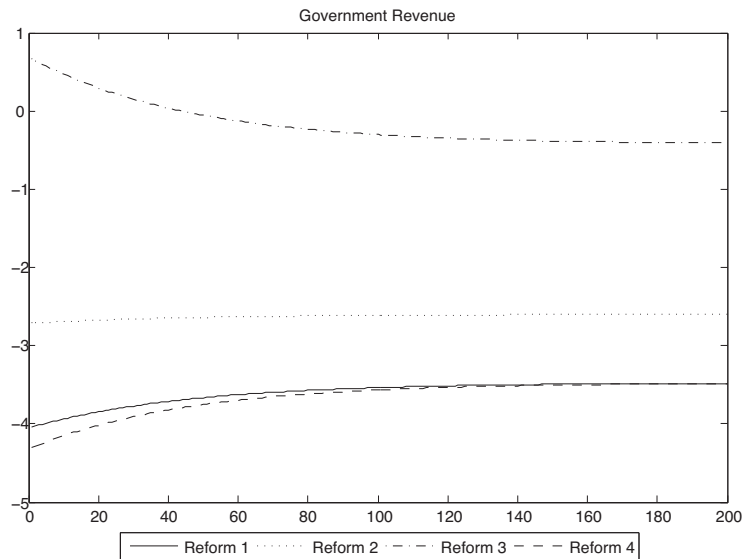


Fig. 2. Results for the government revenues. On the y-axis, percentage changes according to the values of the first steady state. On the x-axis, the time in years after reforms.

periods, and the vertical axis shows the percentage changes relative to the initial steady state. The final percentage changes (when $T = 200$) can be seen in [Table 2](#).

Considering the reform 1, in the first period after the tax change, the labor hours grow sharply ($\approx 3.8\%$) and the consumption also increases at around 2.7% . The welfare variation is calculated at around 0.20% . During the following periods, consumption continues an upward trajectory and the labor hours rise less steeply. These factors allow a gradual increase in welfare variation, which stabilizes at around 1.02% . The capital stock increases gradually to reach a new long-term value 1.52% greater than the first steady state. This behaviour in capital stock reflects the trajectory of investment which grows with more intensity in the short-term. The behaviours of production factors (labor and capital) imply an upward path for the aggregate output which increases initially by approximately 2.2% and ends at around 2.51% .

The results for the second reform are similar to those from reform 1, but with more moderate values. In this simulation, there are lower increases on consumption, capital, labor, and aggregate product. The welfare results are also similar, but less significant than in the first reform. Furthermore, the capital stock remains close to the calibrated value in 2009 (growth of $\approx 0.3\%$).

In the third simulation the results are poorer relatively to the others reforms. Consumption remains close to the calibrated value in 2009, and the labor hours increase slightly. These behaviours contribute to the welfare loss in the second steady state. The increase in the tax rate on revenues from labor-intensive sector affects the capital accumulation, which reduces in the long-term. As a consequence, investment and aggregate output also decrease in the long-term. In the fourth simulation, the numbers are close to the first scenario, with a slightly better results in all variables, except labor hours.

We can calculate the present value of the welfare variation according to the Eq. (35). For the first reform, the present value of the change in welfare is 0.58% (see [Table 2](#)), which means that the reform results in small gains in welfare for the representative household. In the second reform, the changes in consumption and labor hours are lower than those presented in the first scenario, which results in a present value of welfare gain at about 0.51% (less than in reform 1). In the third simulation, the present value of the welfare variation is approximately half of the reform 1 ($\approx 0.28\%$). In the fourth simulation, the welfare gain is 0.53% , which is slightly less than in the first reform. As expected, the worst performance appears in government revenue neutral scenario.

[Fig. 2](#) shows the behavior of the government revenue. In reforms 1, 2 and 4, revenue loss is severe, especially in the short term (-4% (reform 1), -2.70% (reform 2) and -4.3% (reform 4)). In the long-term, government revenue decreases more slowly (reflecting the growth in consumption, capital and product), stabilizing at negative levels (-3.48% (reforms 1 and 4) and -2.6% (reform 2)).

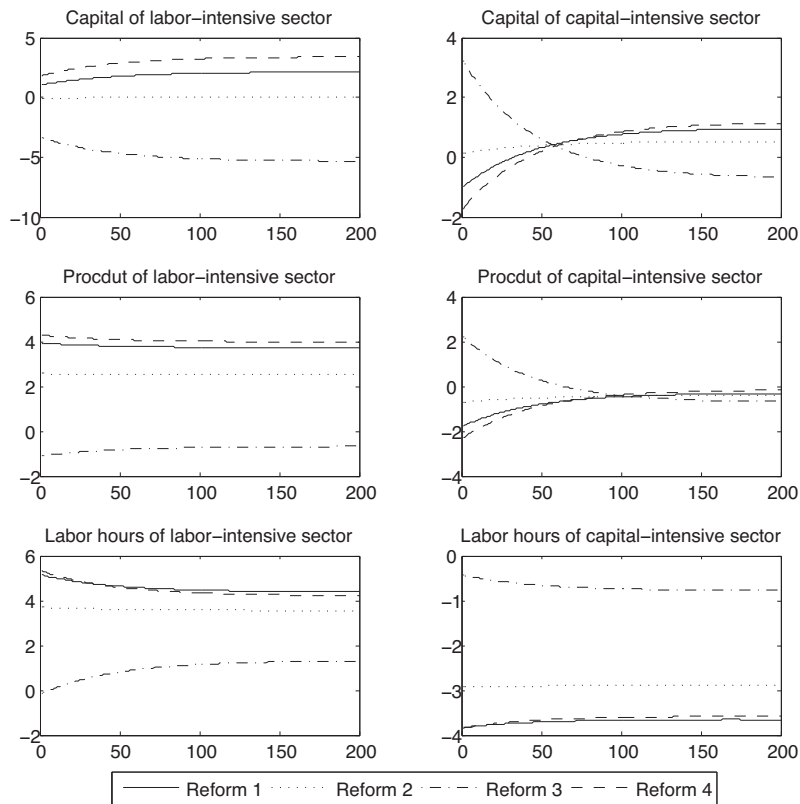


Fig. 3. Sectoral results after each reforms. On the y-axes, the percentage changes relative to the values of the first steady state. On the x-axes, the time in years after reforms.

In the third reform, there is no loss in government revenue. In this scenario, the present value of the differences of the government revenue to its calibrated value in the first steady state is approximately 0.16%.

The sectoral results can be seen in Fig. 3. Looking at the numbers for reform 1, it is noticed that there was a significant increase in employment in the labor-intensive sector (which reaches a peak variation at about 5% in the first period after the reform implementation). The opposite occurs with the capital-intensive sector, which shows a sharp drop in employment (e.g., approximately 3.9% in the short-term). These behaviours reflect the substitution effect on the labor demands between the capital-intensive and the labor-intensive sectors.

For the first reform, in the first period after the tax change, the capital stock of the labor-intensive sector raises at about 1%, while in the capital-intensive sector it decreases close to 1%. As we can see, replacing the payroll tax with a rate of 1% on revenue was beneficial for the labor-intensive sector, which increases employment and capital in relation to the initial equilibrium. These short-term fluctuations impact positively on the product of the labor-intensive sector (growth of approximately 3.9%), and negatively on the product of capital-intensive sector ($\approx -2\%$). In the long-term, the capital and labor demands of the labor-intensive sector increase at about 2.1% and 4.4%, respectively. On the other side, employment of the capital-intensive sector falls more than 3.6%. These factors have direct impact on industry products. In the second steady state, Y_I grows 3.7% and Y_J decreases approximately 0.32%.

The results for the second reform show that, in the short-term, the capital stocks in both sectors (k_I and k_J) remain close to the initial steady state values, while employment grows by 3.65% in labor-intensive sector and decreases by 2.89% in the capital-intensive sector. These short-term effects end up raising the product of the sector I (growth of 2.52%) and slightly reducing the product of the sector J (which falls nearly 0.71%). In the long term, growths of sectoral product are less expressive in reform 2 than in the first simulation. The reform 2 provides a smaller decline in employment of the capital-intensive sector and a less pronounced increase in the employment of the labor-intensive sector than in reform 1. Overall, the results of both reforms show that the labor-intensive sector (which is less taxed

after the reforms) benefits from the payroll tax exemption. The growth of employment and output of the labor-intensive sector are the positive points of the two first reforms.

Looking at the third simulation, the highest level of the revenue tax rate affects the capital factor of the labor-intensive sector. In the short-term, the capital of the labor-intensive sector falls sharply, while the opposite occurs in the capital-intensive sector. But this growth is neutralized in the last periods. The employment in the labor-intensive sector still grows, while the capital-intensive sector drops slightly. As consequence of the short-term fluctuations on capital and labor, the output of the capital-intensive sector grows significantly in the first period, whereas the production of labor-intensive industry reduces. During the later periods, both sectoral products decrease.

The results for the fourth reform are close to the first, but with growth rates slightly higher for the sectoral capital and product, and for the capital-intensive labor hours. Furthermore, relatively to the first scenario, the labor hours growth rates are slightly lower in the labor-intensive sector.

It is important to say that our results depend on the range of values chosen for the constant elasticity of substitution parameter λ (see equation (13)). In fact, there is not an econometric consensus about a reasonable choice for this elasticity, which is a key parameter for our study. In order to overcome this difficulty, an analysis was performed to the parameter λ . The analysis suggests robust results within the range of $\lambda \in [1.7, 2.5]$ ($\sigma \in [1.66, 2.42]$). Those are reasonable values because it is not expected neither perfect substitutes goods nor perfectly complementary goods between labor-intensive and capital-intensive sectors.

6. Conclusion

We have used a neoclassical model to analyze the economic effects on the Brazilian economy of a tax reform that replaces the payroll tax by a tax on revenues of labor-intensive firms. The analysis focused on four reforms. In three of them we used a tax rate of 1%, 2% and 4% on labor-intensive revenue (reforms 1, 2 and 3, respectively). The fourth reform reduces the payroll tax rate in order to keep the same loss of government revenue of the first reform.

The effects of the reforms 1 and 2 have shown some bright spots, such as the growth of capital stock, consumption, the sectoral products, welfare and, most importantly, employment. The labor intensive sector is strongly benefited, but there are a negative impact on government receipts in both reforms. The results for the reduced payroll tax rate reform (reform 4) were very close to the first, but resulting in a lower level of welfare gains in present value. For the government revenue neutral scenario (reform 3), the results are negative, with reduction on capital, product and welfare, with a little employment growth. This fact suggest that the positive effects from the reforms 1 and 2 were exclusively associated with the reduced tax burden generated by these reforms. In other words, the tax change proposed by the reforms can not be an efficient tax choice. The results of the fourth reform reinforces that perception.

The methodology used in this paper has some limitations which are worth mentioning. Firstly, we used a closed economy model. Secondly, the model does not address uncertainty. In both cases, these improvements are left as an alternative for future work. A more important limitation regards the use of a single value for the elasticity of substitution between labor-intensive and capital-intensive goods. Even though the assumption is rather simplistic, the lack of reliable estimates in literature makes it a viable choice. To overcome this problem, a robustness analysis was performed and our results remained robust for a reasonable range of values for the constant elasticity of substitution.

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