Investment Stimulus Policy in Networks*

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This paper investigates the effects of investment stimulus policy in a small open economy real business cycle (RBC) model with production and investment networks. We explore two novel questions: how production and investment networks influence the impact of these policies and the importance of policy design with varying depreciation allowances, time delays, and selected industries. We simulate the impacts of a recently approved depreciation bonus allowance policy in Brazil. By stimulating one buyer industry at a time, we find that service industries have the largest GDP impacts, but stimulating them requires higher foregone revenues from tax waivers, whereas manufacturing and construction industries offer better cost-benefit ratios considering the GDP fiscal multipliers. Assessing policy impacts under Brazil's current tax expenditure limit of R$1.7 billion for accelerated depreciation policy, we find that sector selection criteria substantially influence macroeconomic impacts. Selecting industries ranked by five-year rather than one-year fiscal multipliers results in sustained gains in GDP and labor productivity, as well as increasing GDP fiscal multipliers after the first year.

Keywords: Investment Stimulus Policy, Real Business Cycle (RBC) Model, Networks, Fiscal Policy

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1 Introduction

Investment stimulus is a common policy tool to attenuate business cycle fluctuations. In particular, accelerated depreciation bonus allowances are widely used as investment stimulus. In the United States, for example, the policy of bonus depreciation has been recurrently issued since the enactment of the Job Creation and Worker Assistance Act of 2002. This legislation allows businesses to deduct 30% of the cost of new equipment from their tax base. The subsequent Jobs and Growth Tax Relief Reconciliation Act of 2003 increased this percentage to 50%. These policies have been extended multiple times, and more recently, the Tax Cuts and Jobs Act raised the allowable deduction to 100%.[1]

The Brazilian Congress has enacted Law No. 11.871 of 2024, which authorizes the implementation of an accelerated depreciation investment stimulus policy. This policy permits a deduction from the Corporate Income Tax (IRPJ) and the Social Contribution on Net Profits (CSLL) amounting to up to 50% of the value of new machinery, equipment, or related fixed capital assets[2] in the first year of their deployment, and an additional 50% in the subsequent year, thereby allowing for full depreciation of these assets over two years.

In this paper, we use a dynamic business cycle model to investigate the effects of investment tax incentives by temporary spending allowances. Our paper adds to the literature by asking two questions which have not been considered previously, as far as we are concerned. First, how production and investment networks shape the impact of these investment stimulus policies. Second, the relevance of policy design, by varying percentages of depreciation allowance bonus, time delays, and selected industries.

We address this issues in a small open economy real business cycle (RBC) model with production and investment networks. We simulate how the aggregate impact of investment depreciation bonus allowances can be different according to the industries included in the policy stimulus. Network effects are conditioned by each industry position as a producer and a purchaser of both intermediate inputs and investment goods. For any given design of investment stimulus policy, the policymaker must choose which capital goods to include. These goods correspond to particular supplier industries that produce them, the seller industries. Besides this, government chooses which industries that demand investment goods will be benefited by the policy, the buyer

[1] For a legislative history of these policies in the U.S., see https://crsreports.congress.gov/product/pdf/RL/RL31852.

[2] Exclusions apply to buildings, forestry projects, land, and assets that typically appreciate over time, such as antiques.

industries.

In model calibration, we reproduce data targets for Brazil, a developing country that has a relevant production of investment goods, but is also a net importer of these goods. We use as a reference for policy design the depreciation bonus allowance policy recently announced by Brazilian government in 2024.

In our first set of results, we discuss the sensitivity of the outcomes to the choice of stimulated industries. In order to compare policy impacts under alternative selected industries and policy scenarios, we compute one-year and five-year GDP fiscal multipliers for tax incentives. First, we find that industries that produce investment goods and services included in the policy have the largest positive impacts on value added in the first year, when aggregate demand effects prevail. However, other industries have larger effects over a five-year horizon, with aggregate supply effects via capital accumulation becoming predominant.

Second, we compute the impacts of granting accelerated depreciation bonuses to only one industry at a time. The stimulus to service industries generally exerts the largest effects on GDP. However, the same industries require the highest levels of tax expenditures. Considering GDP fiscal multipliers, manufacturing and construction industries have the best cost-benefit ratios, especially over a five-year horizon.

Our next set of results compares alternative time delay policy designs. Recent temporary investment stimulus policies in the US adopted a 100% bonus allowance for new capital goods. Brazil's recent stimulus policy has adopted a 100% depreciation bonus allowance also. However, in order to smooth the fiscal burden of the policy, Brazilian government adopted a two-year time delay. The depreciation allowance schedule for an investment spending is 50% in the year of purchase of the investment good and the remaining 50% in the next year.

We simulate the impacts of four alternative policy designs: (i) a one year policy with a 100% depreciation allowance in the year of acquisition of investment goods; (ii) a one year policy with a 50% bonus allowance in the year of investment spending and the remaining 50% in the next year; (iii) a two year policy with a 50% bonus allowance in each year, and (iv) a two year policy with a 50% bonus allowance in the first year and 61% in the second year, which replicates the same tax waivers trajectory from design (ii).

Our third key finding is that the design (ii) of accelerated depreciation, a one-year policy with a 50% bonus allowance in the year of investment spending and the remaining 50% in the next year, produces the highest GDP fiscal multiplier in the first year. Furthermore, fiscal multipliers are similar over all designs, (i) to (iv), from the second year onward.

Finally, we simulate the impacts of Brazil's current accelerated depreciation policy for the tax expenditure cap of R$ 1.7 billion from Law No. 11.871 of 2024. We tested two criteria for including industries, based on either the one-year or the five-year GDP fiscal multipliers.

The fourth main finding of this paper is that the sector selection criteria affect macroeconomic impacts. Ranking by the five-year fiscal multiplier generates a smaller effect in the first year but a more favorable trajectory from the second year onward, with a substantial difference in the medium-run fiscal multiplier, GDP, and labor productivity.

Related literature. The main references in the literature that we use to construct our model are Vom Lehn and Winberry (2022) and Winberry (2021).

We consider several sectors interconnected by production networks, via intermediate inputs, and networks for the purchase and sale of investment goods, as in Vom Lehn and Winberry (2022). The authors propose an RBC model to investigate changes in the dynamics of business cycles in the United States, focusing on the interconnections between investment sectors. Although this article does not address accelerated depreciation, it innovates by modeling investment behavior in a DSGE model with production networks. The authors explore how the investment network linking different sectors of the economy influences integrated intersectoral movement during economic cycles. They conclude that the structure of the investment network plays a crucial role in economic fluctuations in the United States. The study highlights the importance of understanding intersectoral relationships for a more accurate analysis of business cycles. However, these authors do not evaluate investment stimulus policies, as we do in our article.

Our model of depreciation bonus allowance is inspired by Winberry (2021). In an RBC model, this article highlights how the unequal nature of investments by firm size can influence companies' responses to investment stimulus policies, including accelerated depreciation. Despite considering firm heterogeneity, this article analyzes only the aggregate economy, without considering inter-industry linkages, as we do in the present work.

Therefore, in addition to its application to Brazil, our paper innovates in relation to the literature by addressing accelerated depreciation considering impacts across multiple sectors. Additionally, we introduce other extensions relative to previous studies available in the literature. First, we allow for the selection of sectors that are buyers and sellers of capital goods in accelerated depreciation policies. Second, we consider a small open economy, including the import and export of goods, unlike the main models in the accelerated depreciation literature, which assume a closed economy. Third, given the design of the Brazilian policy, our model allows for a delay in the bonus allowances for accelerated depreciation. For example, a 100% accelerated depreciation tax credit could be collected 50% in the year of investment and 50% in the following year.

Another relevant reference from literature is Edge and Rudd (2011), which proposes a DSGE model that considers the effects of accelerated depreciation in a New Keynesian framework. The authors emphasize that the presence of nominal price and wage rigidities in the economy amplifies the impacts compared to partial equilibrium analysis, contrary to what was speculated in earlier articles that did not consider general equilibrium effects.

We should also mention articles that investigate the effects of accelerated depreciation policies without using general equilibrium models. The article by Jorgenson and Yun (1991) analyzed the effects of accelerated depreciation on investments in the United States. The authors concluded that accelerated depreciation plays a significant role in stimulating investment, especially in capital-intensive sectors. Another article in this line of research is Chirinko and Wilson (2008), which investigated the effects of accelerated depreciation in the United States during the period from 1952 to 2004. The authors concluded that accelerated depreciation had a positive influence on private investment, indicating that policies allowing for faster recovery of capital costs can indeed stimulate investment. A recent study is Zwick and Mahon (2017). This paper investigates the implications of accelerated depreciation shocks using microdata from more than 120,000 firms. The authors address the effectiveness of these policies in stimulating investment and observe substantial effects between 2001 and 2010 in the United States, with a greater response among smaller firms.

This paper is divided in four sections besides this introduction. In section 2, we derive our model. Section 3 presents data, policy scenarios, and model calibration. In section 4 discuss, we present our simulations and discuss the results. Finally, we present our conclusions.

2 Model

We present the model in recursive form. To simplify the notation, we suppress the time indices in the equations. An apostrophe $'$ represents the value of the next period of that variable, so that if the current value of a variable is X, its value in the next period is denoted by X'.

The economy has N production industries, which will be referenced by the indexes j and

i. Variables with two sector indexes, such as M_{ij}, denote a product from industry i that is purchased by industry j. Vectors are represented in bold, such as $\mathbf{I_j} = [I_{ij}]_{N\text{x}1}$, which represents the set of purchases by industry j of investment goods produced in industry $i = 1, \dots, N$.

2.1 Technology

The firms in each industry operate under competitive conditions, with production functions exhibiting constant returns to scale. The following equations present the production technology of each industry j. The production function is:

$$Q_j = A(K_j^{\alpha_j} L_j^{1-\alpha_j})^{\theta_j} M_j^{1-\theta_j} \tag{1}$$

with $\alpha_j, \theta_j \in (0,1)$, where Q_j is the quantity produced in the industry, A is the total factor productivity, K_j is the stock of capital accumulated by the firm from industry j, L_j is the labor force employed, and M_j is the bundle of intermediate inputs of each firm in j.

We assume that the total factor productivity A is common to all industries and subject to stochastic shocks, with law of motion given by:

$$\log A' = \rho_a \log A + \varepsilon_a, \quad \text{with } \varepsilon_a \sim \mathcal{N}(0, \sigma_a^2), \quad \rho_a \in (0,1) \tag{2}$$

Capital stock is accumulated by the own representative firm in each industries, following:

$$K_j' = (1-\delta_j)K_j + I_j - \varphi(K_j, K_j')K_j \tag{3}$$

$$\varphi(K_j, K_j') = \frac{\phi}{2}\left(\frac{K_j' - K_j}{K_j}\right)^2 \tag{4}$$

where $\varphi(K_j, K_j')$ is an adjustment cost of the capital stock, which depends on the current capital stock K_j and the net investment $K_j' - K_j$, with $\phi > 0$, I_j is the sectoral investment, and $\delta_j \in (0,1)$ is the industry-specific capital depreciation rate.

The production and investment networks of the economy are determined by the technologies of industry aggregators of intermediate inputs and investment goods:

$$M_j = \prod_{i=1}^{N} M_{ij}^{\gamma_{ij}}, \quad \text{with } \sum_{i=1}^{N} \gamma_{ij} = 1 \tag{5}$$

$$I_j = \prod_{i=1}^{N} I_{ij}^{\lambda_{ij}}, \quad \text{with } \sum_{i=1}^{N} \lambda_{ij} = 1 \tag{6}$$

where $\gamma_{ij}, \lambda_{ij} \in (0, 1)$.

2.2 Profits tax and depreciation allowances

We assume that the representative firm in each industry pays a tax τ_j on its profits in each period, which combines the Corporate Income Tax (IRPJ) and the Social Contribution on Net Profit (CSLL).[3]

Let us define the variables I_{ij} and P_i as, respectively, the investment of sector j in capital good i and the market price of good i. The stock D_j includes the capital stock of all past investments of sector j not expensed yet, except for the amounts in R_j. The stock R_j is a variable created to model the particular design of the 2024 investment stimulus policy in Brazil. R_j equals the value of investments made under a 100% depreciation bonus allowance policy, but not expensed in the year the investment was made.

The cost of capital for the purpose of computing profit taxes is determined by applying depreciation allowance rates to the current investment $\sum_i P_i I_{ij}$ and the not expensed capital stocks, D_j and R_j.

The depreciation allowances $\hat{\delta}_{ij}^I$ applies in the current period investment expenditure $P_i I_{ij}$. Under accelerated depreciation policies, potentially specific to the buying and selling industries, this rate may differ from $\hat{\delta}_j$, which is the regular depreciation allowance rate for the capital stock of industry j. In periods without accelerated depreciation policies, all the non-depreciated portion $1 - \hat{\delta}_{ij}^I$ of $P_i I_{ij}$ will be accounted for in the following period in the stock D_j'. In all periods, the stock D_j is always depreciated at the rate of $\hat{\delta}_j$, which is constant.

[3] In the Brazilian economy, within each industry there are productive units operating under other tax regimes besides the standard formal tax regime for Brazilian firm, the "lucro real". These firms operating under alternative regimes, as well as informal firms, will not be directly benefited by the accelerated depreciation policy. We calibrate τ_j as the effective rate that reproduces in each industry the observed ratio between the collection of IRPJ and CSLL from the "lucro real" tax regime and the gross output of all productive units in that industry.

2.3 Bonus Depreciation Allowance Policy

The government establishes an accelerated depreciation policy by choosing two variables specific by seller industry i and buyer industry j of investment goods: x_{ij} e $\hat{\delta}^R_{ij}$.

The first policy variable, $x_{ij} \in [0,1]$, is the value of the accelerated depreciation bonus, the increase in the depreciation allowance relative to the usual depreciation allowance rate $\hat{\delta}_j$ of that industry. The depreciation allowance rate for the investment $\hat{\delta}^I_{ij}$ is expressed in terms of x_{ij} by:

$$\hat{\delta}^I_{ij} = x_{ij} + (1 - x_{ij})\hat{\delta}_j \tag{7}$$

with a null bonus $x_{ij} = 0$ in periods without accelerated depreciation, or if the sale of capital goods produced by i and purchased by j has not been selected for the policy.

Therefore, if we consider that the government defines a single percentage $\hat{\delta}^I$ of accelerated depreciation for all selected industries, such that $\hat{\delta}^I_{ij} = \hat{\delta}^I$ for the selected i, j transactions and $\hat{\delta}^I_{ij} = \hat{\delta}_j$ for other cases, then we can express the bonus as:

$$x_{ij} = \frac{\hat{\delta}^I_{ij} - \hat{\delta}_j}{1 - \hat{\delta}_j} \tag{8}$$

The second policy variable - $\hat{\delta}^R_{ij} \in [0,1)$ - is the share of present investment that will be added to R'_j and depreciated with one time lag to the next year. We consider that if government chooses a delayed depreciation allowance scheme, all transactions i, j of capital goods selected will present a delayed depreciation at the second year such that the percentage of both years sum up to 100%. Thus:

$$\hat{\delta}^R_{ij} = \begin{cases} 1 - \hat{\delta}^I_{ij}, & \text{if there is a delay and } I_{ij} \text{ is selected for accelerated depreciation} \\ 0, & \text{otherwise} \end{cases} \tag{9}$$

which, considering equation (7), can be rewritten as:

$$\hat{\delta}^R_{ij} = \begin{cases} (1 - \hat{\delta}_j)(1 - x_{ij}), & \text{if there is a delay and } I_{ij} \text{ is selected for accelerated depreciation} \\ 0, & \text{otherwise} \end{cases} \tag{10}$$

For example, consider that the government chooses an accelerated depreciation policy of 60%

in 2024 ($\hat{\delta}^I_{ij} = 0.6$ *if* I_{ij} *selected*). If there is no delay in accelerated depreciation, the remaining value will be depreciated sequentially in subsequent years, under the usual depreciation allowance rates of each industry. If the government chooses a delayed 100% accelerated depreciation policy, however, the remaining 40% will be depreciated in 2025, so that $\hat{\delta}^R_{ij} = 0.4$ for all the I_{ij} benefited.

2.4 Firm's Problem

The firm in sector $j = 1, \dots, N$ takes as given the government policies and the current and expected prices, and chooses sequences of inputs and production factors in order to maximize the expected present value of its profits, $\mathbf{E_0}\left[\sum_{t=0}^{\infty} \Lambda_t \Pi_{j,t}\right]$. Since the firms are owned by representative households, they use the households' stochastic discount factor Λ_t to discount the expected flow of profits to present value.

We can solve the intratemporal problem of optimal choices for the composition of bundles of intermediate inputs separately from the intertemporal problem. Let the sectoral price indexes of intermediate inputs p^M_j be implicitly defined by:

$$p^M_j M_j = \sum_{i=1}^{N} P_i M_{ij} \tag{11}$$

then the optimal demand of industry j for intermediate inputs of industry i is:

$$M_{ij} = \frac{\gamma_{ij} p^M_j M_j}{P_i}, \qquad \text{with} \quad p^M_j = \prod_{i=1}^{N} \left(\frac{P_i}{\gamma_{ij}}\right)^{\gamma_{ij}} \tag{12}$$

Current profits of firms Π_j in industry j is:

$$\Pi_j = (1-\tau_j)(p_j Q_j - p^M_j M_j - w L_j) - \sum_{i=1}^{N} (1 - \hat{\tau}_j \hat{\delta}^I_{ij}) P_i I_{ij} + \hat{\tau}_j \hat{\delta}_j D_j + \hat{\tau}_j R_j \tag{13}$$

where p_j is the price of the good produced in industry j and w_t is the wage. Note that the rate $\hat{\tau}_j$ used for the deduction of the capital cost in the profit tax is potentially different from the rate τ_j, which was assumed for convenience for the calibration of the model, we explain later.

Let $\mathbf{I_j} = [I_{1j}, I_{2j}, \dots, I_{Nj}]$ be the vector of investment goods acquired by the firm in industry j, $\mathbf{x_j} = [x_{1j}, x_{2j}, \dots, x_{Nj}]$ be the vector of accelerated depreciation bonuses for these acquisitions, and $\hat{\delta}^{\mathbf{R}}_{\mathbf{j}} = [\hat{\delta}^R_{1j}, \hat{\delta}^R_{2j}, \dots, \hat{\delta}^R_{Nj}]$ be the portion of depreciation allowances for these purchases delayed to the next year. We can then write the intertemporal problem of the firms in recursive form as:

$$V_j(K_j, D_j, R_j, \mathbf{x_j}, \hat{\delta}_{\mathbf{j}}^{\mathbf{R}}, s) = \max_{M_j, L_j, \mathbf{I_j}} \left\{ \Pi_j + \mathbf{E_0} \left[\Lambda(s') V_j(K'_j, D'_j, R'_j, \mathbf{x_j}', \hat{\delta}_{\mathbf{j}}^{\mathbf{R}\prime}, s') \right] \right\}$$

subject to

$$D'_j = (1 - \hat{\delta}_j) D_j + \sum_{i=1}^{N} (1 - \hat{\delta}^I_{ij} - \hat{\delta}^R_{ij}) P_i I_{ij} \tag{14}$$

$$R'_j = \sum_{i=1}^{N} \hat{\delta}^R_{ij} P_i I_{ij} \tag{15}$$

and equations from (1) to (4), (6), (7) and (13)

where s groups the variables that make up the aggregate state of the economy, including aggregate shocks A and A_x, all prices, and the laws of motion of these aggregate variables. $\Lambda(s)$ is the stochastic discount factor and $\mathbf{E_0}$ denotes the conditional expectation operator given the information available at the current time.

2.5 International Trade and Domestic Absorption

Our economic system is a small open economy that trades with the rest of the world. Each good j produced domestically is a imperfect substitute for the corresponding good j produced abroad and the elasticity of substitution between domestic and foreign goods indexed by j is unitary. The demand of the rest of the world for the domestically produced goods is subject to a terms of trade shock A_x, common to all exported goods. The quantum exported Q^x_j of each good is expressed by:

$$Q^x_j = \frac{A_x \Gamma_j}{p_j} \tag{16}$$

$$\log A'_x = \rho_x \log A_x + \varepsilon_x, \quad \text{with } \varepsilon_x \sim \mathcal{N}(0, \sigma^2_x), \quad \rho_x \in (0, 1) \tag{17}$$

where $\Gamma_j \geq 0$ is a constant related to external demand.

The share of non exported domestic production of each good $Q^h_j = Q_j - Q^x_j$ is totally absorbed by domestic firms, which also acquire imported products Q^m_j. The production function and profits of domestic absorption firms are given by:

$$Q_j^a = (Q_j^m)^{\upsilon_j}(Q_j^h)^{1-\upsilon_j} \tag{18}$$

$$\Pi_j^a = P_j Q_j^a - p_j^m Q_j^m - p_j Q_j^h \tag{19}$$

with $\upsilon_j \in [0,1]$ where P_j is the producer price in the domestic market and p_j^m is the corresponding price of the imported good from abroad. Domestic absorption firms take prices as given and choose Q_j^h e Q_j^m to maximize their profits, which are equal to zero in equilibrium. Thus we have the following demand functions for the imported goods, domestic production and domestic supply prices:

$$Q_j^m = \upsilon_j \frac{P_j Q_j^a}{p_j^m} \tag{20}$$

$$Q_j = (1-\upsilon_j)\frac{P_j Q_j^a}{p_j} + Q_j^x \tag{21}$$

$$P_j = \left(\frac{p_j^m}{\upsilon_j}\right)^{\upsilon_j}\left(\frac{p_j}{1-\upsilon_j}\right)^{1-\upsilon_j} \tag{22}$$

2.6 Government

Once the bonus depreciation policy is defined, in each period the government collects taxes on firm's profits and transfer them to households as a *lump sum* T equal to:

$$T = \sum_{j=1}^{N} \tau_j \left(p_j Q_j - p_j^M M_j - w L_j\right) - \sum_{j=1}^{N} \hat{\tau}_j \left(\sum_{i=1}^{N} \hat{\delta}_{ij}^I P_i I_{ij} + \hat{\delta}_j D_j + R_j\right) \tag{23}$$

2.7 Households

Households maximize $\mathbf{E_0}\left[\sum_{t=0}^{\infty} \beta^t u(C_t, L_t)\right]$, where:

$$u(C,L) = \log C - \chi \frac{L^{1+\varsigma}}{1+\varsigma} \tag{24}$$

$$C = \prod_{j=1}^{N} C_j^{\xi_j}, \quad \text{with} \sum_{j=1}^{N} \xi_j = 1 \tag{25}$$

The optimal choice for composition of the consumption bundle implies:

$$P_j C_j = \xi_j C, \quad \text{where} \prod_{j=1}^{N} \left(\frac{P_j}{\xi_j}\right)^{\xi_j} = 1 \tag{26}$$

that is, we normalized the price index of the aggregate consumption bundle to unit.

Besides wages wL, households receive government transfers T and dividends Π_j from firms in each industry. Households also have access to international financial markets and accumulate wealth in bonds B measured in units of the consumption bundle, which pay interests r in each period.

We represent the problem in the recursive form as follows:

$$\vartheta(B,s) = \max_{C,L,B'} \left\{ u(C,L) + \beta \mathbf{E_0}[\vartheta(B',s')] \right\} \tag{27}$$

subject to

$$C + B' = wL + \sum_{j=1}^{N} \Pi_j + T + (1+r)B \tag{28}$$

with a no-Ponzi condition.

First order conditions and envelope condition imply:

$$\chi L^{\varsigma} = \frac{w}{C} \tag{29}$$

$$1 = \mathbf{E_0}\left[\beta \frac{C}{C'}(1+r')\right] \tag{30}$$

an then we define the stochastic discount factor as

$$\Lambda(s) = \beta \frac{C}{C'} \tag{31}$$

We assume that international capital markets are complete and national resident's access to it is perfect, so that the interest rate r is constant under the small open economy assumption. In this case, the stochastic discount factor is constant also and equals the discount rate. The interest rate and the discount rate are related by $\beta = 1/(1+r)$.

2.8 Market clearing

Market clearing conditions are:

$$L = \sum_{j=1}^{N} L_j \tag{32}$$

$$Q_j^a = C_j + \sum_{i=1}^{N} M_{ji} + \sum_{i=1}^{N} I_{ji}, \qquad \text{for } j = 1, \dots, J \tag{33}$$

$$TB = \sum_{j=1}^{N} \left(p_j Q_j^x - p_j^m Q_j^m \right) \tag{34}$$

$$B' = (1 + r)B + TB \tag{35}$$

Equation (32) establishes equilibrium in the supply and demand for labor. Feasibility conditions described in equation (33) refer to the equality between domestic supply and demand and holds for all j goods. We define the trade balance in equation (34) and the equilibrium in the balance of payments in (35). In (35), changes in the capital account equals the accumulation of international bonds by resident households.

2.9 Value Added and Aggregate Investment

Let the nominal value added of industry j be defined by:

$$p_j^Y Y_j = p_j Q_j - p_j^M M_j \tag{36}$$

then by defining the real value added of each industry by Divisia indexes, we can shown that the real value added per industry Y_j can be expressed in each period of the model by:

$$Y_j = A^{\frac{1}{\theta_j}} K_j^{\alpha_j} L_j^{1-\alpha_j} \tag{37}$$

We define the real GDP of the economy by aggregating the sectoral value-added using a Törnqvist index.

For the investment, we can show that the solution to the firms' problem implies the definition of a real sectoral investment index I_j based on the optimal choices of I_{ij}. Analogous to GDP, we define the aggregate investment of the economy by applying the Törnqvist index to the sectoral investments I_j.

3 Data and calibration

3.1 Industry data

We use five distinct data sources to calibrate industry-specific parameters in our model: i) Input-Output Tables (IOTs) estimated by Alves-Passoni and Freitas (2023), available for the period of 2000 to 2019; ii) Capital Flows Tables (CFT), or "Matriz de Absorção de Investimentos", also available for the period 2000-2019 and estimated by Miguez and Freitas (2021); iii) the Capital Stock Tables available for the period 2005-19 estimated by Souza Junior and Cornelio (2020); iv) Consolidated Sectoral Data - by CNAE[4] Group and Taxation Regime, available for the years 2019 and 2020, according to RFB (2021); v) finally, data from the Supply and Use Tables (SUTs) for the period 2000-19, according to IBGE (2021).

We use current price CFTs for 91 products and 42 industries. We also use IOTs for 25 products and 40 industries at current prices. Capital Stock Tables are available at the level of disaggregation of 51 sectors and 27 products for the period 2005-2019, however we only used this data for 2019. The SUTs refer to the backdated series from the Brazilian Geography and Statistics Institute (IBGE), which is available for 51 sectors and 107 products. Additionally, federal revenue data available are disaggregated into 68 distinct industries.

Our first step was harmonization of all data to the level of 40 industries. Furthermore, we use the market share matrix obtained from the IOTs to transform CFTs into industry-by-industry format.

We use the the Capital Stock Tables available at constant relative prices of 2010 provided by Souza Junior and Cornelio (2020) for the initial sectoral capital stock K_j and industry-specific depreciation rates. From the SUTs, we use value added by industry data to find capital and labor compensation shares.

Finally, we compute the profits tax rate by industry using data from Brazilian's Internal Revenue Service, the "Receita Federal do Brasil" (RFB), on effective tax collection in 2019 for firms under the standard Brazilian tax regime for firms, which is called the "real profits" regime ("lucro real", in Portuguese). In Brazil, firms that operate under two alternative formal tax regimes, the "lucro presumido" and "SIMPLES", as well as informal firms, can not be included in the accelerated depreciation policy. Section 3.3 provides further details about how we use these data to calibrate model parameters.

[4]National Classification of Economic Activities

3.2 Policy scenarios

As we pointed out in the Introduction, the Brazilian Congress has authorized the implementation of a Bonus Depreciation Allowance policy. We have build the model in this paper to support the Ministry of Development, Industry, Commerce, and Services (MDIC) in the formulation of this law. The MDIC provided us with some alternative scenarios specifying which industries would benefit, and we have calibrated the model based on their baseline selection of industries and their corresponding estimates of revenues foregone from the tax waivers. Thus, the simulations carried out with the model supported the policymakers that created this law.

The law established a deduction for Corporate Income Tax (IRPJ) and Social Contribution on Net Income (CSLL) of up to 50% of the value of new machinery, equipment, or related fixed capital assets in 2024 and the remaining 50% in 2025. The total fiscal revenue available for expenditure under this policy for 2024 is capped at R$ 1.7 billion. The exact implementation - that is, which industries will benefit - is still under debate and will be defined by a Government Decree.

Table 1 presents the industry aggregation level used in the simulations and selected industries under alternative scenarios. In the third column of Table 1, we show the aggregation choice we made so that we could harmonize different data sources. In column (A) we present the industries that produce capital goods and services, which are used as investments. We identified these industries based on the Capital Flows Tables. Column (B) presents the industries that sell the investment goods selected for accelerated depreciation. This column is used to identify the goods stimulated by the policy within the model and we compiled it from information provided by MDIC. The last two columns represent alternative scenarios with selected industries stimulated to purchase capital goods by depreciation bonus allowances. Column (C) shows the standard selection of buyer industries from MDIC, which we use to calibrate the initial fiscal impact of the policy and for the simulations of alternative policy designs in section 4.2. Finally, column (D) indicates the industries that were considered in at least one of the MDIC's scenarios of stimulated buyer industries. In section 4.3, we use this extendend selection from column D as our baseline for reducing the number of stimulated industries to respect the tax waiver cap from the approved law.

Table 1: *Correspondence from 40 to 51 aggregation levels and industry selection*

No.	Industries	51 Industries	A	B	C	D
1	Agriculture	1 + 2	X			
2	Oil/Gas Extraction	3	X			X
3	Iron Extraction	4				X
4	Other Extraction	5				X
5	Food and Beverages	6				X
6	Tobacco	7			X	X
7	Textiles	8			X	X
8	Apparel/Accessories	9			X	X
9	Footwear/Leather	10			X	X
10	Wood	11			X	X
11	Pulp/Paper	12			X	X
12	Printing and Reproductions	13			X	X
13	Refining	14			X	X
14	Biofuels	15				X
15	Chemicals	16 + 17			X	X
16	Pharmaceuticals	18			X	X
17	Hygiene and Cleaning	20			X	X
18	Various Chemicals	19 + 21 + 22			X	X
19	Rubber and Plastic	23			X	X
20	Cement and Others	24			X	X
21	Steel and Derivatives	25			X	X
22	Non-ferrous Metals	26			X	X
23	Metal Products	27	X	X	X	X
24	Various Industries	28 + 30 + 34	X	X	X	X
25	Electrical/Electronics	29	X	X	X	X
26	Automobiles	31	X	X	X	X
27	Parts/Accessories	32	X	X	X	X
28	Other Transportation Equipment	33	X	X	X	X
29	Utilities	35			X	X
30	Construction	36	X		X	X
31	Commerce	37	X			
32	Transportation/Storage	38			X	X
33	Accommodation and Food Services	43				
34	ICT and Information	39	X	X	X	X
35	Financial Intermediation	40				
36	Real Estate Activities and Rentals	41				
37	Various Services	42 + 44 + 47 + 48	X			
38	Private Education	45				
39	Private Health	46				
40	Public Sector	49 + 50 + 51	X			

Notes: The first three columns show the correspondence between IBGE's 51 industries backdated series and the 40 industries considered in this paper. The last four columns present alternative criteria for industry classification and selection into the Brazilian investment stimulus policy by MDIC. (A) All producers of capital goods and services. (B) Selected sellers of investment goods and services. (C) Buyer of investment goods: standard baseline MDIC selection, which is the main scenario used for preliminary estimates and model calibration. (D) Buyer of investment goods: extended baseline MDIC selection, which includes all industries considered in at least one of the alternative MDIC preliminary scenarios.

3.3 Calibration

We assume the model period is one year, as in Vom Lehn and Winberry (2022), because this is the periodicity of our industry data.

Table 2 presents normalizations of some model parameters. For the parameters of the utility function associated with labor supply, following Vom Lehn and Winberry (2022), we impose $\chi = 1$ and $\varsigma = 0$. That is, the Frisch elasticity $1/\varsigma$ is infinite, which implies indivisible labor at the individual level so that we can interpret fluctuations in L in terms of employment instead of hours worked.

Table 2: *Normalizations*

Parameter	Value	Reference
χ	1	Vom Lehn and Winberry (2022)
ς	0	Vom Lehn and Winberry (2022)
p_j^m	p^m	External prices to the economy

Notes: Normalization of labor supply parameters χ and ς. The prices of imported goods p_j^m are assumed to be equal for any industries $j = 1, \ldots, J$.

As pointed out in previously, the numeraire good is the consumption aggregate. Prices of imported goods are external to the economy, thus we assume that all are equal, $p_j^m = p^m$. The price of imported goods relative to the consumption numeraire, p^m, can change out of the steady state equilibrium. In the steady state, we normalize $p^m/C = 1$.

In Table 3, we present the calibration of industry-specific parameters. As discussed in section 3.1, we set the values for externally calibrated parameters by using data from Supply and Use Tables (SUTs), Input-Output Tables (IOTs), Capital Flows Tables (CFTs), and capital stocks by industry. All data have IBGE as the primary source, with the IOTs 2000-2019 constructed by Alves-Passoni and Freitas (2023), the CFTs 2000-2019 by Miguez and Freitas (2021), and the industry-specific depreciation rates 2005-2019 and capital stocks 2019 by Souza Junior and Cornelio (2020). We assume that the depreciation allowance rates $\hat{\delta}_j$ for capital stocks of each industry are equal to the corresponding economic depreciation rates δ_j.

The corporate profit tax rate τ_j by industry is calibrated internally to the model. In steady-state equilibrium, τ_j must equal the ratio between the collection of IRPJ and CSLL among firms under the standard Brazilian tax regime for firms in industry j and the gross output of all firms in industry j. Because we are not modeling alternative formal tax regimes in Brazil and informal firms, both of which do not directly benefit from accelerated bonus allowances, we only use tax collection from firms in the standard regime to compute τ_j. We use tax revenue data from 2019 from the Brazilian Federal Revenue Service (RFB, 2021) and gross output by industry of 2019 from IBGE (2021).

Table 3: *Calibration, industry-specific parameters*

Parameter	Target	Sources
External to the model:		
α_j	$\frac{\textit{Gross Operating Surplus (GOS) in } j}{\textit{GOS + wages in } j}$	SUTs 2000-2019, IBGE (2021)
θ_j	$\frac{\textit{Value Added (VA) in } j}{\textit{VA + Intermediate consumption in } j}$	IOTs/SUTs 2000-19, IBGE (2021), Alves-Passoni and Freitas (2023)
ξ_j	$\frac{\textit{Final consumption expenditure in } j}{\textit{Aggregate final consumption expenditure}}$	IOTs 2000-19, Alves-Passoni and Freitas (2023)
υ_j	$\frac{\textit{Imported supply in in } j}{\textit{Total supply in } j}$	IOTs 2000-19, Alves-Passoni and Freitas (2023)
Γ_j	$\frac{\textit{Exports in } j}{\textit{Gross output in } j}$	IOTs 2000-19, Alves-Passoni and Freitas (2023)
γ_{ij}	$\frac{\textit{Expenditure of } j \textit{ on inputs produced in } i}{\textit{Intermediate consumption in } j}$	IOTs 2000-19, Alves-Passoni and Freitas (2023)
λ_{ij}	$\frac{\textit{Expenditure in } j \textit{ on investment goods from } i}{\textit{Total investment in sector } j}$	CFTs 2000-19 Miguez and Freitas (2021)
$\delta_j, \hat{\delta}_j$	*Sectoral depreciation rate*	Sectoral capital stocks 2000-19 Souza Junior and Cornelio (2020)
Internal to the model:		
$\tau_j, \hat{\tau}_j$	$\frac{\textit{IRPJ + CSLL, standard tax regime firms in } j}{\textit{Gross output in } j}$	RFB (2021)

Notes: See section 3.1 for data sources.

The tax rate $\hat{\tau}_j$, which is used to compute capital cost deductions, is initially equal to the corresponding tax rate τ_j. However, the assumption of equality between the capital depreciation rate δ_j and the bonus allowance $\hat{\delta}_j$ due to data constraints, which is not necessarily true, may lead to inconsistencies in simulating the fiscal impacts of accelerated depreciation policies.

In order to get around this issue, we use estimates of the fiscal impact of the accelerated depreciation policy from Brazil's Federal Revenue Service ("Receita Federal do Brasil") to calibrate $\hat{\tau}_j$ internally to the model. Brazilian Ministry of Development, Industry, Commerce, and Services (MDIC) provided us with these estimates, which are based on the standard baseline selection of buyer industries shown in column C of Table 1. In this case, revenue foregone due to tax waivers would be R$ 7.201 billion, according to these estimates. To determine the values of $\hat{\tau}_j$, we multiply each tax rate τ_j by 0.42, as indicated in Table 4. With this modification, the tax expenditure computed in the model under the standard baseline industry selection for a 100% accelerated depreciation shock, with a 50% fiscal deduction in the present year and 50% in the subsequent year, is R$ 7.26 billion in the current year.

Table 4: *Calibration, adjustments and GDP ratios*

Variable	Multiplier	Parameters	Data	Model
Trade balance / GDP	0.87	υ_j	0	0
Intermediate Inputs / GDP	1.046	θ_j	104.5%	104.6%
Profits tax (standard regime) / GDP	1.07	τ_j	2.9%	2.9%
Revenue foregone from tax waiver (base scenario, RFB's estimates)	0.42	$\hat{\tau}_j$	R$ 7.20 bi	R$ 7.26 bi

Notes: We target aggregate data moments by multiplying all industry-specific parameters in column 'Parameters' by the corresponding values in column 'Multiplier'.

We apply other multiplicative adjustments linearly to industry-specific parameters to make sure that some aggregate variables respect proportions relative to GDP as observed in the averages from 2000 to 2019 for the Brazilian economy data. Table 4 displays these adjustments.

Table 5 presents the parameterization of the autoregressive processes.

Table 5: *Calibration, autoregressive shocks*

Parameter	**Value**	**Reference series**
ρ_a	0.849	Total factor productivity
σ_a	0.009	Total factor productivity
ρ_z	0.577	Exported value
σ_z	0.076	Exported value

Notes: Parameters for stochastic process of total factor productivity and terms of trade.

We compute the parameters in Table 5 according to the autoregressive processes of equations (2) and (17). In order to find parameters ρ_a and σ_a, we compute the series A for total factor productivity (TFP) using a definition that is analogous to equation (37), given by:

$$\log A = -\bar{\theta}\left[\bar{\alpha}\log\frac{K}{Y} + (1-\bar{\alpha})\log\frac{L}{Y}\right] \tag{38}$$

where $\bar{\theta}$ is the average between 2000 and 2019 of the GDP share in the gross output, and $\bar{\alpha}$ is the average from 2000 to 2019 of the share of gross operating surplus (GOS) in the sum of wages and GOS. The measure of wages is the total compensation of labor, including contributions. The series L/Y uses in the numerator the sum of the number of workers in all industries and in the denominator the GDP from IBGE (2021), at 2010 prices, extracted from Ipeadata.[5]. The series K/Y is the capital-product ratio, at 2010 prices, also extracted from Ipeadata. All the variables mentioned refer to the aggregate of the Brazilian economy and for the years of 2000 to 2019.

We assume a linear trend for the log of TFP, which we remove before computing the autoregressive process in (2). In addition to the linear trend, we have evaluated higher-order polynomials for the trend. All of them, however, implied a reduced model adherence to the standard deviation of GDP calculated from the data, presented in Table 6.

For the terms of trade shock A_x, following equation (16), we use the annual total export value series from 2000 to 2019. As the corresponding variable in the model is the nominal export value, considering the consumption aggregate as the numeraire good, we deflate this series by the consumption price index IPCA. Then we compute the parameters in equation (17) after extracting the linear trend in the log of the series.

Table 6: *Other parameters and non targeted moments*

Parameter	Value	Moment	Data	Model
Calibrated parameters:				
β	0.9346	Real interest rate	7%	7%
ϕ	1.36	Std. Dev. (Investment)	7.94%	7.96%
Non targeted moments (2000-2019):				
		Std. Dev. (GDP)	2.63%	2.12%
		Std. Dev. $\left(\frac{\text{Trade balance}}{\text{GDP}}\right)$	1.87%	1.28%
		Investment / GDP	18.5%	18.8%
		Consumption / GDP	81.5%	81.2%
		Exports / GDP	13.0%	13.8%
		Imports / GDP	13.0%	13.8%
		Wages / (Wages + GOS)	56.9%	56.4%

Notes: Calibration for parameters β and ϕ. Aggregate moments not targeted in model calibration, data averages for the period 2000-2019 in Brazil and steady-state ratios for the model. GOS refers to Gross Operation Surplus in the data and capital compensation in the model.

Finally, Table 6 presents the remaining parameters and the model's fit to some moments that were not targeted in the calibration. The discount rate β is calibrated externally to the model based on the interest rate, for which we assume a value of 7%. The parameter ϕ, which regulates

[5]http://www.ipeadata.gov.br/Default.aspx

the cost of capital adjustment, is calibrated internally to the model, by targeting the standard deviation of investment. The investment series is the gross fixed capital formation at 2010 prices from IBGE, from 2000 to 2019, available from Ipeadata.

In the model, we simulate the impacts of the same sequence of TFP and export shocks from 2000 to 2019 used in the parameterization of the autoregressive processes. Then, we calculate the standard deviation of total investment, which we compute by using a Törnqvist index to aggregate the investment by industry as generated by the model. We use a similar procedure to compare the model with the data for the standard deviation of GDP. For all the remaining non targeted variables, we compute ratios using nominal values in the data and the model.

The standard deviations of both GDP and trade balance to GDP ratio are higher in the data than in the model, but their order of magnitude is close. All the other non targeted aggregate ratios are similar in the model and in the data.

4 Results

We present three sets of results. In section 4.1, we discuss the heterogeneity of impacts between industries of the bonus depreciation allowance policy, as well as criteria to select benefited industries. Section 4.2 compares impacts on economic activity of alternative policy designs. Finally, in Section 4.3 we simulate the recently approved investment stimulus policy in Brazil, considering the maximum total tax waiver bound authorized by national congress, under alternative criteria to select industries.

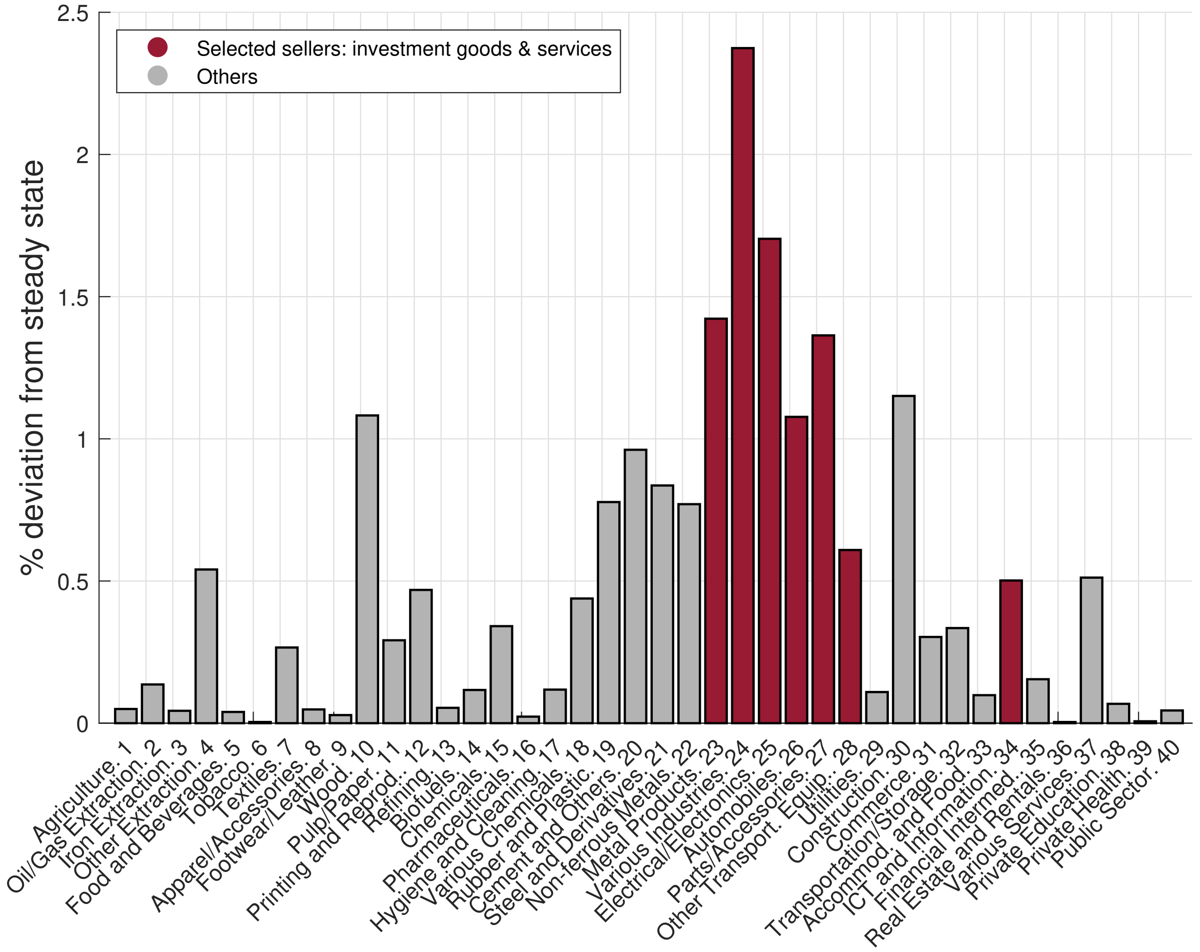
4.1 Industry selection and network effects

In Figure 1, we present first-year impacts on value-added by industry for a one-year 100% depreciation bonus allowance in investments, with all industries included as benefiting buyers of investment goods and services, except public administration activities.

In the short run, industries that produce capital goods included in the policy make the greatest gains in value added, in general. Investment stimulus directly affects aggregate demand in these industries. Nonetheless, other industries also experience positive aggregate demand impacts, that are mediated by the production and investment networks connecting them.

Over the years after the policy is adopted, however, the relative benefit to industries can be quite different. Figure 2 shows, for the same one-year stimulus as in Figure 1, the accumulated

Figure 1: ***Value added by industry, first year***
(One year 100% bonus for all industries)



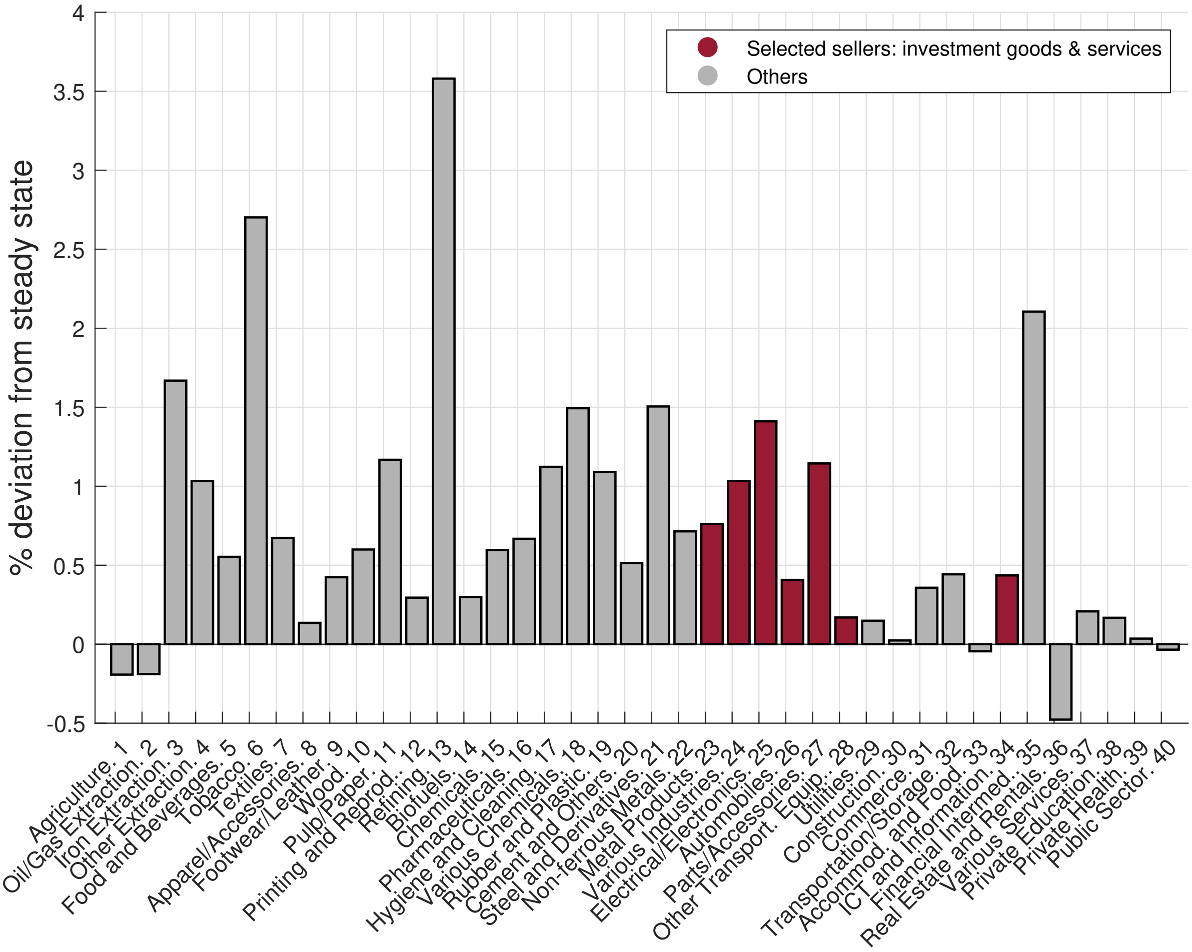
Notes: The y-axis shows % changes in value added by industry in the first year after a one-year investment stimulus with a 100% depreciation bonus allowance for all industries. The x-axis represents industries ordered by codes in Table 1. The highlighted bars represent industries that produce capital goods and services included in the stimulus policy.

effect over five years on value added of the industries. We highlight three aspects observed in this figure.

First, we note that in five years, the impact on the value added of several industries is equal to or exceeds the positive effects on industries producing capital goods. Stimulating investments promote aggregate demand in the short run and increase capital stock and productive capacity over longer horizons. As industries benefiting from each of these effects differ, relative gains change over time.

Second, comparing Figures 1 and 2, the accumulated effects over five years on the value added of industries producing investment goods are smaller than the gains in the first year. This occurs because the stimulus policy prompts buyers to anticipate purchases of capital goods that would be made later, generating a reduction in subsequent years' production of these goods.

Figure 2: ***Value added by industry, accumulated in five years***
(One year 100% bonus for all industries)



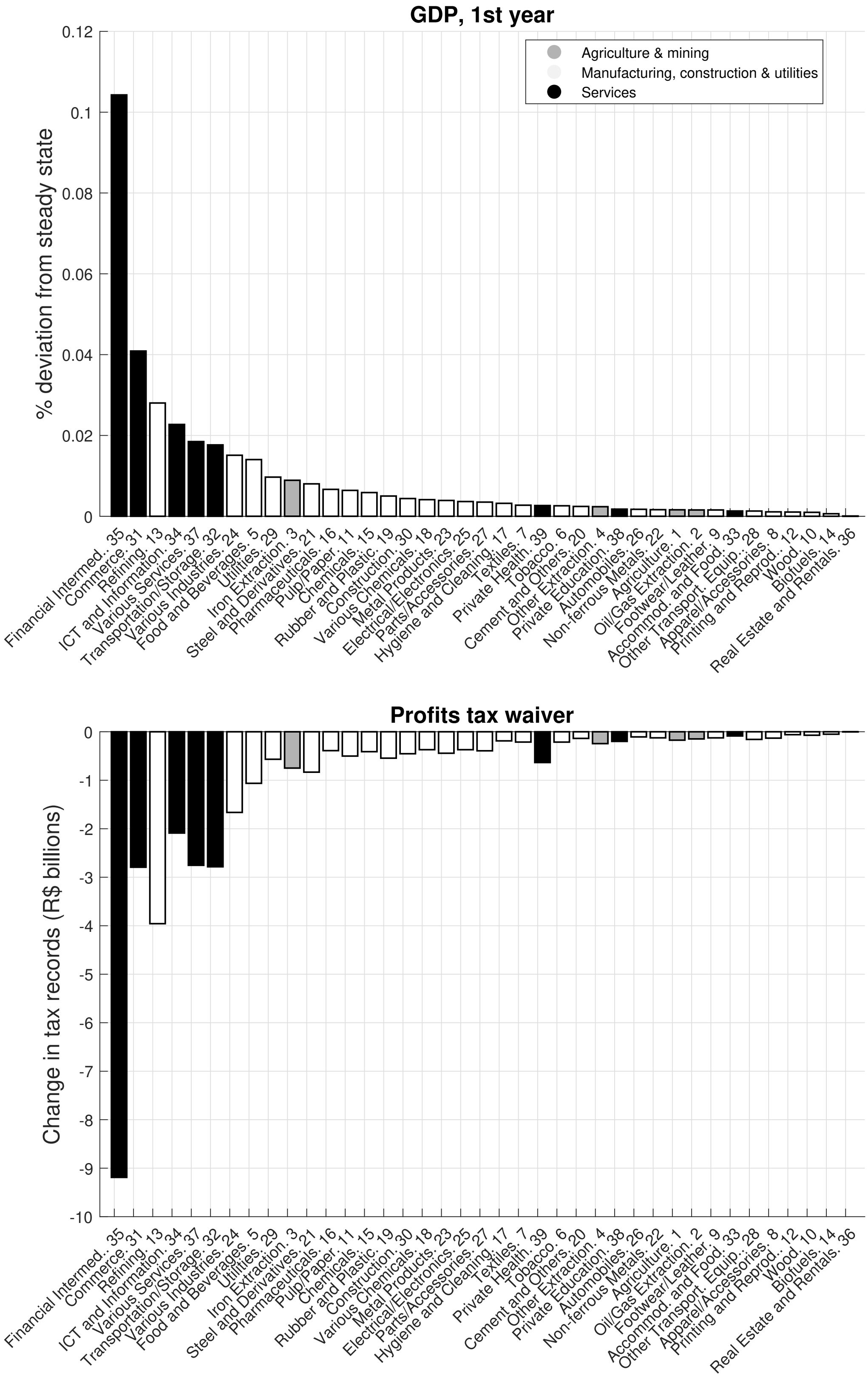
Notes: The y-axis shows % changes in value added by industry accumulated in five years after a one-year investment stimulus with a 100% depreciation bonus allowance for all industries. The x-axis represents industries ordered by codes in Table 1. The highlighted bars represent industries that produce capital goods and services included in the stimulus policy.

Third, some industries experience a reduction in value added over five years. This is the result of substitution between goods from different sectors in final demand. For example, real estate activities is associated with the supply of buildings, a capital good not covered by the accelerated investment depreciation policy.

Given the heterogeneity of impacts on sectors, it is straightforward to question the convenience of restricting the benefits of accelerated depreciation to a subset of buyer industries of investment goods and services.

Figures 3 and 4 present relevant data for discussing the cost-benefit potential of stimulating different sectors to promote aggregate economic activity. We repeat the simulation in Figures 1 and 2 a few times but restrict the benefit of accelerated depreciation to only one sector that purchases investment goods in each simulation.

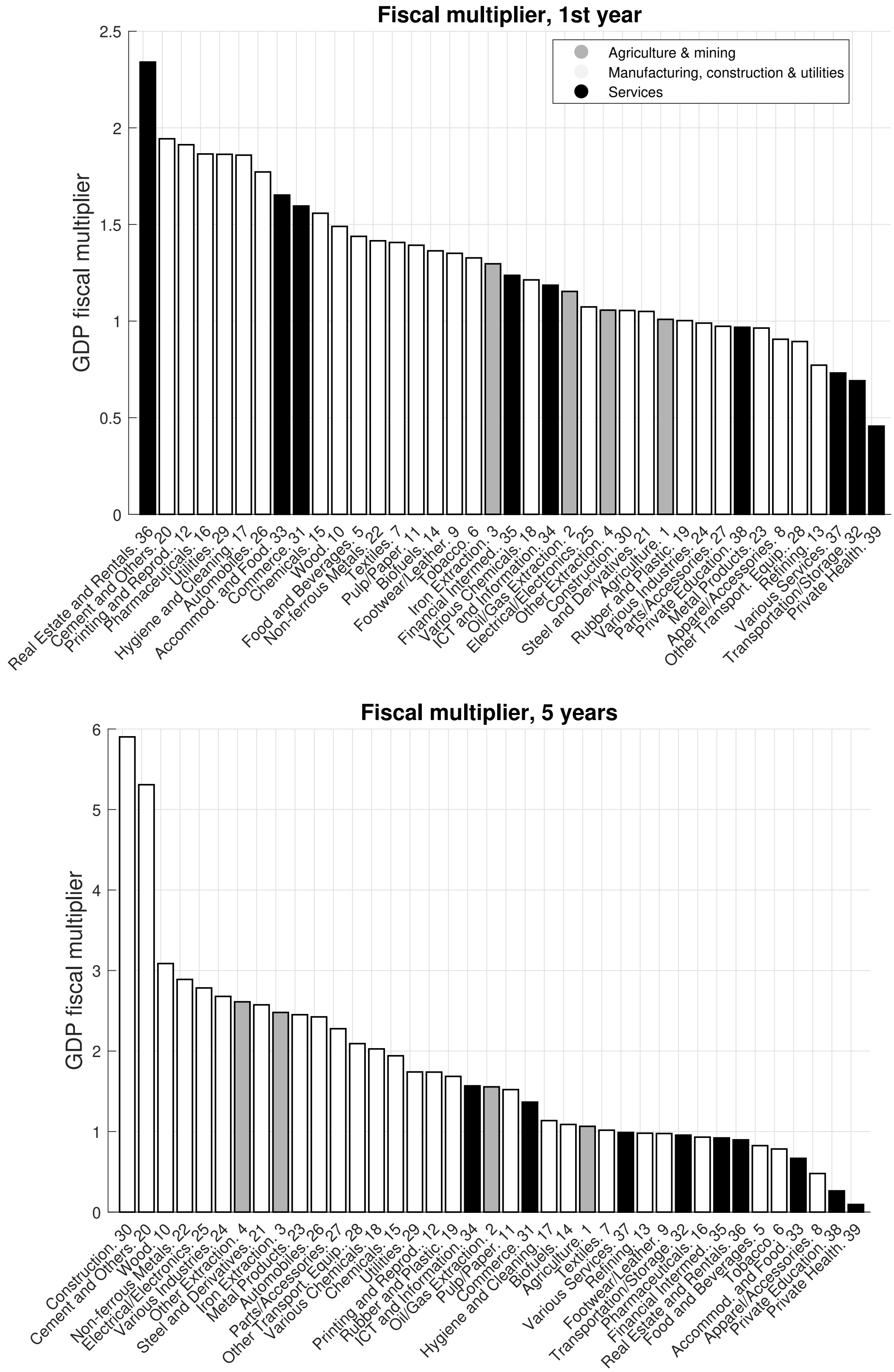
Figure 3: ***Stimulus for a single industry: 1st year GDP and tax waiver***
(One year 100% bonus, for one industry at a time)



Notes: Each bar represents a simulation in which only one industry receives a 100% accelerated depreciation bonus for one year. The x-axis indicates the industry that received the bonus in each simulation in order of magnitude of the impact on GDP in the first year after the stimulus. Industries in agriculture, livestock, and mining are highlighted in gray; industries in manufacturing, construction, and utilities are highlighted in white; and service activities are highlighted in black. In the first panel, the y-axis indicates the percentage gain of GDP in the first year of each simulation. In the second panel, the y-axis shows tax exemptions in year of policy in Brazilian R$ for each simulation.

Figure 4: ***Stimulus for a single industry: GDP fiscal multipliers***

(One year 100% bonus, for one industry at a time)



Notes: Each bar represents a simulation in which only one industry receives a 100% accelerated depreciation bonus for one year. The x-axis indicates the industry that received the bonus in each simulation. In the first panel, the x-axis order simulations using the first-year fiscal multiplier, which is computed as GDP changes over the tax waiver. In the second panel, the x-axis order simulations according to the five-year fiscal multiplier, which is computed as present-value GDP changes in five years over present-value change in profits tax revenues in five years. In both panels, the y-axis presents the corresponding fiscal multiplier values. Industries in agriculture, livestock, and mining are highlighted in gray; industries in manufacturing, construction, and utilities are highlighted in white; and service activities are highlighted in black.

Figure 3 depicts the impacts on GDP in the first year and the cost of the tax waiver for each simulation. To facilitate comparisons, we highlight the classification of industries into three macro sectors: A) Agriculture, livestock, and mining; B) Manufacturing, construction, and utilities; and C) Services. There is a predominance of services among the industries that produce the highest effects on GDP in a year if they are encouraged to invest. Financial intermediation and trade activities have the largest impacts. However, the same group of activities with the highest GDP impacts are also those that are most costly to stimulate in terms of required tax exemptions.

For a improved cost-benefit analysis, Figure 4 presents the results of the ratio between the two quantities. In the first panel, industries are ordered using the one-year fiscal multiplier. Compared with Figure 3, there is a substantial increase in manufacturing industries' presence among top positions. This movement is strengthened over a five-year horizon, as shown in the second panel of Figure 4. The construction industry has the highest five-year fiscal multiplier, with manufacturing dominating the remaining top positions.

4.2 Alternative time delay policy designs

This section examines the effects of investment stimulus policy by depreciation bonus allowances under alternative policy designs for time delays. For all the simulations in this section, the selected buyer industries of investment goods and services are those in the standard baseline scenario from Brazilian government, depicted in column C of Table 1, and the seller industries are those in column B of this table.

We simulate four alternative policy designs:

i) **1 year, 100%:** of the investments made in the year, 100% are depreciated in the same year.

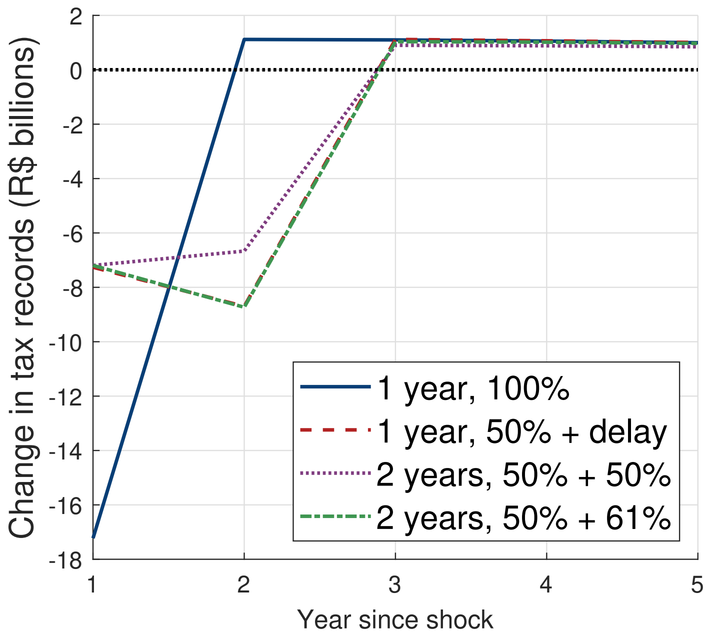
ii) **1 year, 50% + delay:** of the investments made in the year, 50% are depreciated in the same year. The remaining 50% of the investments will be depreciated in the following year. In other words, there is a delay in the remainder of the value to be depreciated, with the invested value being depreciated in two installments.

iii) **2 years, 50% + 50%:** of the investments made in the year, 50% are depreciated in the same year. In the following year, new investments made also have 50% of their value depreciated. Unlike the previous policy design, each year's investment does not have its entire value depreciated in one or two years. However, investments made over two years will have 50% of their value depreciated each year.

iv) **2 years, 50% + 61%:** of the investments made in the year, 50% are depreciated in the same year. In the following year, new investments made have 61% of their value depreciated. This scenario is similar to policy design (iii), but but we change bonus allowances in each year in order to reproduce the same trajectory of foregone tax revenues as in design (ii).

We first consider the impact on total profits tax revenues, shown in Figure 5. The stimulus from accelerated depreciation comes at the cost of reduced revenues from IRPJ and CSLL taxes for companies under "lucro real", the standard Brazilian tax regime for firms. Under policy design (i), foregone revenues are concentrated in the first year, amounting to R$ 17.2 billions. For all the other designs, total tax waivers are close to R$ 7.2 billions in the first year. Figure 5 also indicates that part of the tax waiver is recovered in the next years. This is due to the increase in production after the investment stimulus, which reflects in revenue growth, reversing part of the initial foregone revenues.

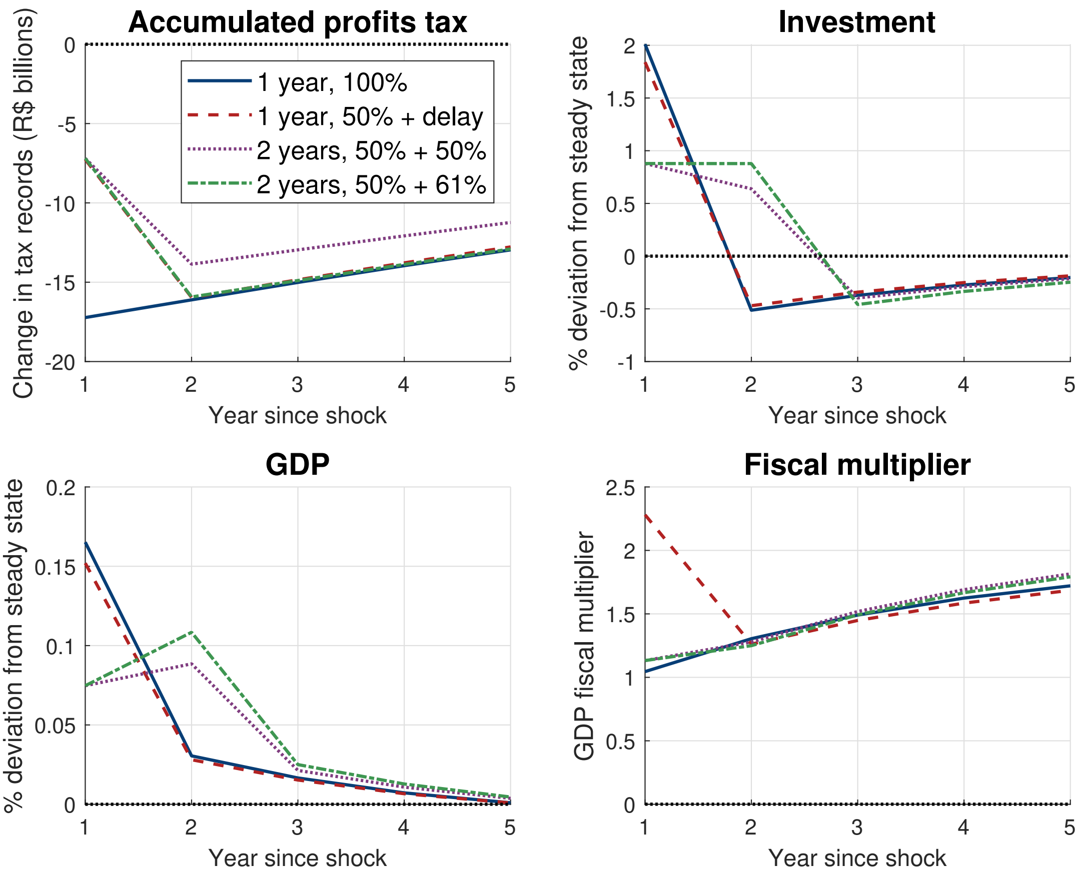
Figure 5: *Profits tax*
(Standard baseline industry selection)



Notes: Change in CSLL and IRPF profits tax revenues under alternative policy designs. Baseline industry selection: sellers in column B and buyers in column C from Table 1. Blue straight line refers to policy design (i), red dashed line to design (ii), purple dotted line to design (iii), and green dash-dotted line to design (iv).

Figure 6 shows the impacts in accumulated profit taxes, Investment, GDP, and the fiscal multiplier. Foregone revenues in the first year are significantly smaller for designs (ii), (iii), and (iv), as in these policy designs the tax waiver associated with accelerated depreciation occurs partly in the first year and partly in the second year. Effects in economic activity are very similar for policy designs (i) and (ii), but the distribution of foregone revenues is smoothed in policy design (ii). Effects in economic activity, represented in Figure 6 by investment and GDP, are lower in the first year but higher in the second year in designs (iii) and (iv).

Figure 6: *Production and tax records*
(Standard baseline industry selection)



Notes: Impacts in accumulated profit taxes, Investment, GDP, and the fiscal multiplier under alternative policy designs. Fiscal multiplier computed as present-value GDP changes over present-value change in profits tax revenues. Baseline industry selection: sellers in column B and buyers in column C from Table 1. Blue straight line refers to policy design (i), red dashed line to design (ii), purple dotted line to design (iii), and green dash-dotted line to design (iv).

The last panel in Figure 6 presents GDP fiscal multipliers over alternative time horizons. In the first year, the fiscal multiplier is close to 2.3 for policy design (ii) and 1.1 in the other designs. In design (ii), the main aggregate demand positive economic impacts of a 100% depreciation bonus allowance are concentrated in the first year, but the fiscal cost of tax waivers are smoothed over two years. From the second year onwards, however, fiscal multipliers are very similar for all the alternative policy designs. They rise from circa of 1.25 in year two to 1.7 or 1.8 in year five. Fiscal multipliers rise after the second year because the government revenue losses from tax waivers are concentrated in the first one or two years, but there is a sustained increase in both profits taxation and GDP over the five years horizon.

Thus, policy design (iii) provides a smoother distribution of economic activity gains over the years. However, policy design (ii) results in higher short run cost-benefit ratio according to GDP fiscal multipliers, without significant disadvantage over longer horizons under the same criteria.

4.3 Brazilian investment stimulus policy

In this section, we present simulations of the potential effects of Brazil's recently proposed accelerated depreciation policy on investment. In early 2024, the Brazilian government established the general guidelines for the policy, which were approved by Brazil's national congress through Law No. 11,871 of 2024.

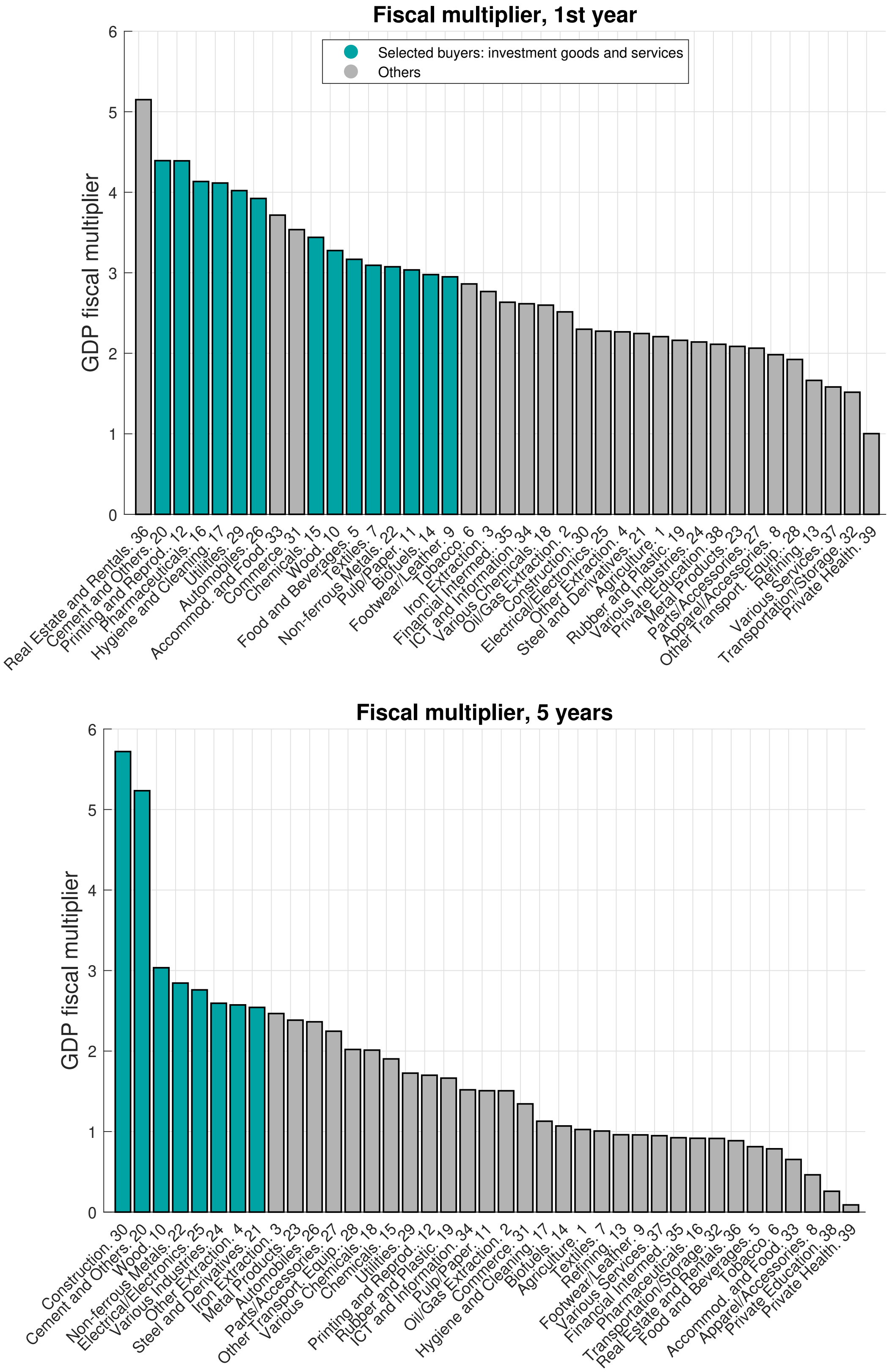
Compared with the scenarios tested previously, the most notable difference was the substantial reduction in tax expenditure expected for the policy. Law No. 11.871 of 2024 establishes a maximum tax waiver of R$1.7 billion in the year the policy is implemented. This is substantially lower than the preliminary estimates of R$7.2 billions, which considered the baseline selection of industries in the government's initial scenario. The definition of industries eligible for accelerated depreciation on the purchase of investment goods, however, will still be determined by a decree, which has not yet been issued at the time of writing this paper.

We simulate an accelerated depreciation policy that imposes a maximum tax waiver of R$1.7 billion in the first year by restricting the number of industries covered by the incentive to purchase investment goods and services. We consider two criteria for industry selection — one-year and five-year fiscal multipliers. In both cases, we restrict the selection of buyer industries to those that are part of at least one of the Brazilian government's preliminary scenarios, which corresponds to the expanded selection presented in column D of Table 1. The policy design, as determined by Law, is a one year stimulus with a 50% depreciation bonus allowance in the year of purchase of the investment goods and the remaining 50% in the next year, design (ii) from section 4.2.

Figure 7 shows the industries covered by the two criteria, illustrating the ordering by multipliers in each case.

Figure 7: ***Stimulus for single selected industries: GDP fiscal multipliers***

(One year 50% bonus + delay, for one industry at a time)

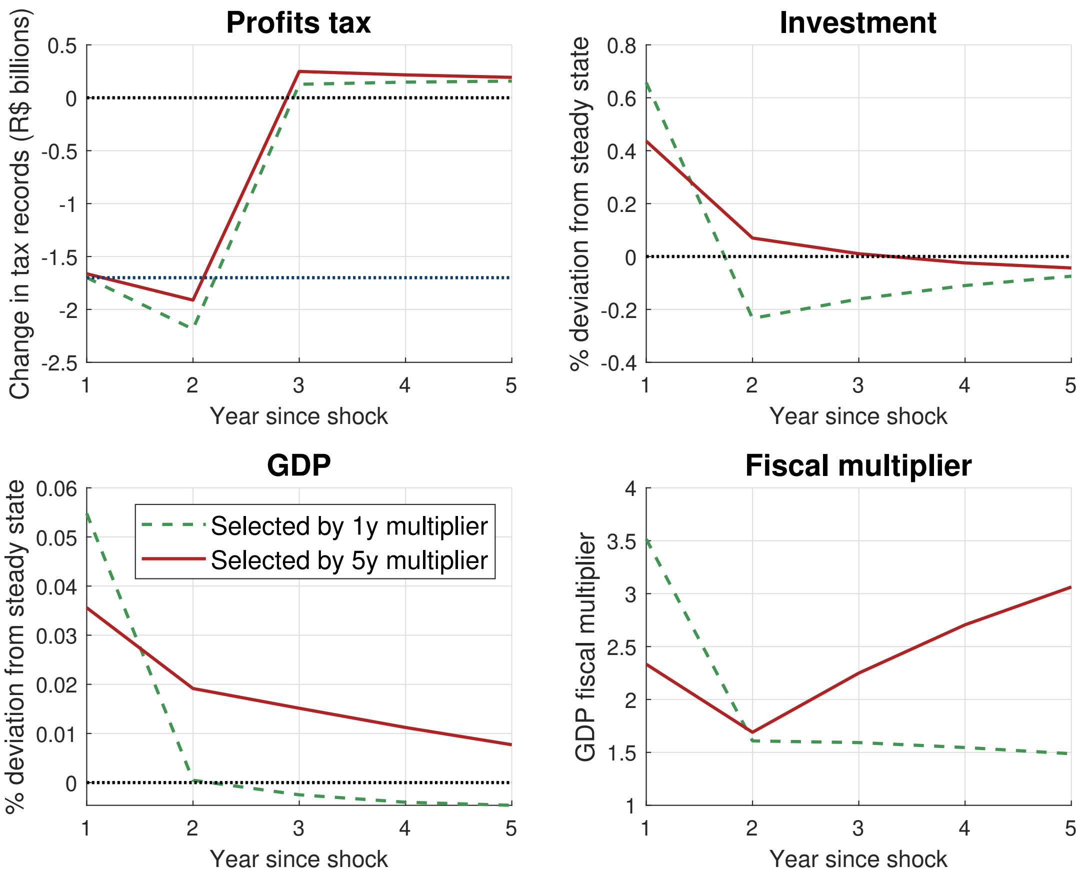


Notes: Each bar represents a simulation in which only one industry receives a 50% accelerated depreciation bonus in the year of purchase of the investment good and the remaining 50% in the next year. The x-axis indicates the industry that received the bonus in each simulation. In the first panel, the x-axis order simulations using the first-year fiscal multiplier, which is computed as GDP changes over the tax waiver. In the second panel, the x-axis order simulations according to the five-year fiscal multiplier, which is computed as present-value GDP changes in five years over present-value change in profits tax revenues in five years. In both panels, the y-axis presents the corresponding fiscal multiplier values. The highlighted bars represent industries included in the stimulus policy as buyers of capital goods and services.

Regarding the number of industries covered, the one-year fiscal multiplier criterion allows the selection of 14 industries under the R$ 1.7 billion bound, while the five-years fiscal multiplier criterion results in 8 industries. In the first criterion, three services industries were disregarded because they were not included in any of the Brazilian government's preliminary scenarios: "36. Real Estate and Rentals", "33. Accommodation and food services", and "31. Commerce". By the second criterion, no industry was disregarded for this reason.

Figures 8 and 9 shows effects on macroeconomic aggregates related to tax collection, production, employment, and international trade. As seen in the first panel of Figure 8, the trajectory of tax records is similar in the two scenarios considered, with a revenue foregone from tax waivers of R$1.7 billion in the first year, circa of R$2 billions in the second year, and a small increase in tax collection compared to the initial equilibrium after the third year.

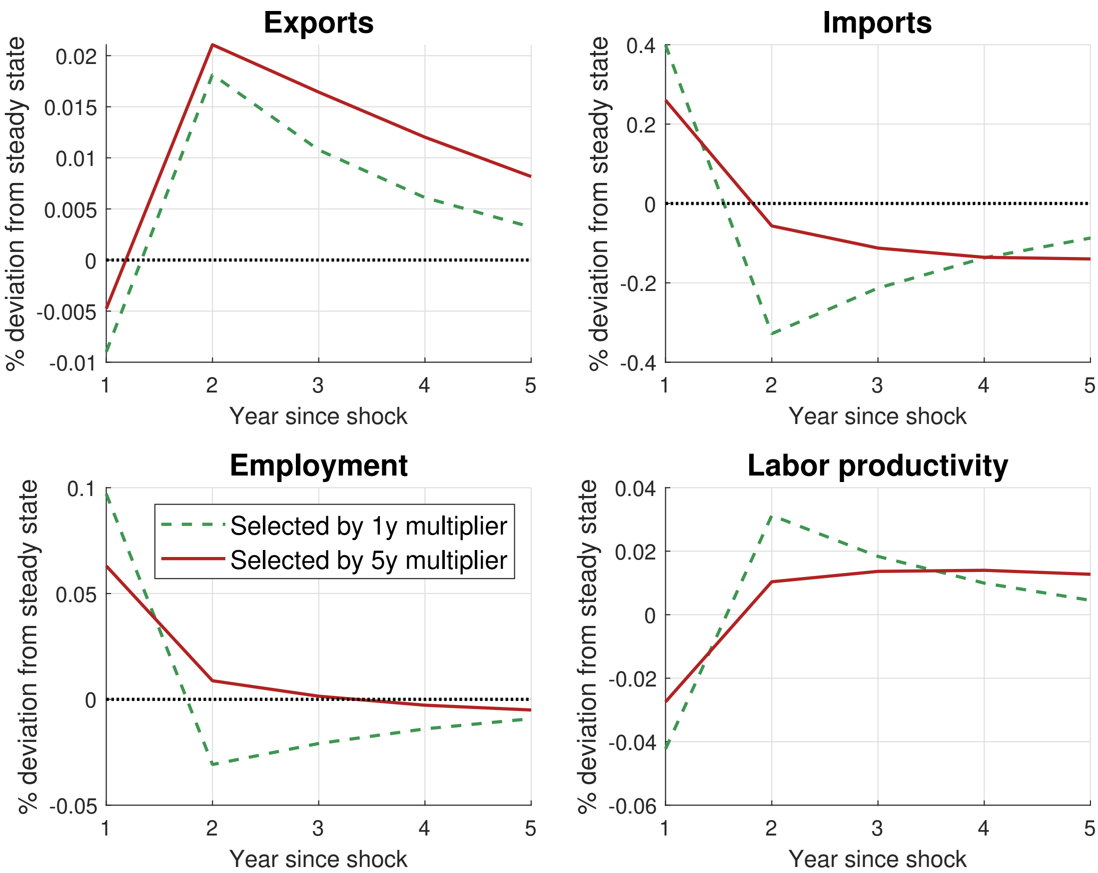
Figure 8: ***Production and tax records, bounded tax waiver***
(One year stimulus, 50% bonus in the 1st year + 50% delay in the 2nd year)



Notes: Aggregate effects of a one year investment stimulus policy under alternative criteria for industry selection subject to an upper bond of R$ 1.7 billion for total tax waiver in the year of policy adoption. Selected industries receive a 50% accelerated depreciation bonus in the year in which they purchase investment goods and the remaining 50% in the next year. The green dotted lines represent results for industries ranked by the one-year fiscal multiplier, and the red solid lines represent results for industries ranked by the five-year fiscal multiplier.

From Figure 8, the initial effect on economic activity is greater under the one-year fiscal

Figure 9: ***International trade and employment, bounded tax waiver***
(One year stimulus, 50% bonus in the 1st year + 50% delay in the 2nd year)



Notes: Aggregate effects of a one year investment stimulus policy under alternative criteria for industry selection subject to an upper bond of R$ 1.7 billion for total tax waiver in the year of policy adoption. Selected industries receive a 50% accelerated depreciation bonus in the year in which they purchase investment goods and the remaining 50% in the next year. The green dotted lines represent results for industries ranked by the one-year fiscal multiplier, and the red solid lines represent results for industries ranked by the five-year fiscal multiplier.

multiplier criterion, with an increase of 0.66% in investment and 0.055% in GDP, compared with 0.44% and 0.036%, respectively, under the five-year multiplier criterion. The trajectory from the second year onwards, on the other hand, is more adverse under the first criterion, with sharp falls in investment and GDP. However, using the five-year multiplier criterion, the reduction in both is smoothed out, with sustained gains in GDP. The same reasoning applies to employment and labor productivity trajectories in Figure 9. Choosing industries by the five-year multiplier criterion results in sustained gains in labor productivity.

There are slightly negative impacts on aggregate exports in the first year for both criteria, as shown in Figure 9, but a stronger positive effect in exports after the second year. Regarding the impact on imports, there is an increase in the impact year, which one could attribute to the growth in imported investment goods. However, after that imports fall bellow the initial level.

Finally, we discuss GDP fiscal multipliers from the last panel of Figure 8.The fiscal multiplier in the initial year is 3.5 for the first criterion and 2.3 for the second criterion. Both are reduced to 1.6 or 1.7 in the second year due to policy design. The initial gain in investment and GDP is concentrated in the first year, but revenue loss is diluted over two years. From the third year onwards, however, the trajectories differ markedly for the two criteria. With the industries chosen according to the highest one-year multipliers, the value of the multiplier stagnates at 1.6 to 1.5 after the second year. However, if sectors are chosen according to the five-year multiplier criteria, the GDP fiscal multiplier rises year by year, reaching above 3 in the fifth year.

5 Conclusions

Is this paper we used a dynamic business cycle model to investigate the effects of temporary bonus allowance investment tax incentives. investment tax incentives by temporary spending allowances. Our model and simulations addressed two key issues: how production and investment networks shape the impact of investment stimulus policies and the relevance of the policy design, i.e., which industries and depreciation time delays imply the best cost-benefit relations as measured by GDP fiscal multipliers. We also simulate Brazil's recent accelerated depreciation allowance policy under alternative criteria for industry selection.

We obtained four main results. First, industries that sell selected investment goods have the greatest short run positive effects on value added, but other industries have stronger impacts over the five-year horizon. This because aggregate supply effects through capital accumulation prevail over longer horizons and firms anticipate future acquisitions of investment goods. Second, if we stimulate one industry at a time, services industries prevail between the highest positive GDP impacts, but when we consider the fiscal costs of tax waivers, manufacturing and construction industries prevail with the best cost-benefit ratios as measured by GDP fiscal multipliers. Third, the policy design with a one year stimulus with a bonus allowance 50% in the year of investment acquisition and remaining 50% in the next year has the highest short run fiscal multiplier and similar five-year multipliers compared to other designs. Fourth, under the tax waiver upper bound approved in the recent Brazilian accelerated bonus depreciation policy, industry selection by five-year multipliers results in sustained gains in GDP, labor productivity, and fiscal multipliers compared with industry selection by one-year fiscal multipliers.

References

Alves-Passoni, Patieene and Fabio Freitas (2023), "Estimação de matrizes insumo-produto anuais para o brasil no sistema de contas nacionais referência 2010." *Pesquisa e Planejamento Econômico*, 25, 117–165.

Chirinko, Robert S and Daniel J Wilson (2008), "State investment tax incentives: A zero-sum game?" *Journal of Public Economics*, 92, 2362–2384.

Edge, Rochelle M and Jeremy B Rudd (2011), "General-equilibrium effects of investment tax incentives." *Journal of Monetary Economics*, 58, 564–577.

IBGE (2021), *Sistema de Contas Nacionais: Brasil / Tabelas de Recursos e Usos.* Disponível em: <https://www.ibge.gov.br/estatisticas/economicas/comercio/9052-sistema-de-contas-nacionais-brasil.html>. Acesso em: 23 nov. 2023.

Jorgenson, Dale Weldeau and Kun-Young Yun (1991), *Tax reform and the cost of capital.* Oxford University Press.

Miguez, Thiago and Fabio Freitas (2021), "Matrizes de absorção de investimento (MAIs): metodologia de estimação para o sistema de contas nacionais referência 2010." *Texto para Discussão IE-UFRJ*, 24.

RFB (2021), *Dados Setoriais Consolidados - Por Grupo CNAE e Forma de Tributação.* Disponível em: <https://www.gov.br/receitafederal/pt-br/centrais-de-conteudo/publicacoes/estudos/pessoas-juridicas-por-setor/estudos-setoriais-das-pessoas-juridicas/dados-setoriais-consolidados-2019-e-2020/tabela-8-por-grupo-cnae-e-forma-de-tributacao.xlsx/view>. Acesso em: 23 nov. 2023.

Souza Junior, José Ronaldo de Castro and Felipe Moraes Cornelio (2020), "Estoque de capital fixo no brasil: Séries desagregadas anuais, trimestrais e mensais." *Texto para Discussão - Instituto de Pesquisa Econômica Aplicada*, 2580.

Vom Lehn, Christian and Thomas Winberry (2022), "The investment network, sectoral comovement, and the changing us business cycle." *The Quarterly Journal of Economics*, 137, 387–433.

Winberry, Thomas (2021), "Lumpy investment, business cycles, and stimulus policy." *American Economic Review*, 111, 364–396.

Zwick, Eric and James Mahon (2017), "Tax policy and heterogeneous investment behavior." *American Economic Review*, 107, 217–248.