Corporate Tax Rates, Allocative Efficiency, and Aggregate Productivity*

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July 20, 2021

Abstract

This paper quantifies the impact of effective corporate tax rates on aggregate total factor productivity (TFP). Using Chilean manufacturing data, we document a large dispersion in the effective tax rate faced by firms and a mass of firms facing a 0 percent tax rate. We incorporate these findings into a standard monopolistic competition model with corporate tax rates. We find that eliminating corporate tax rates increases TFP between 4 and 11 percent. We consider counterfactual policies in which all firms face the same tax rate and find a monotonically decreasing relationship between the level of the tax rate and TFP. *JEL Codes:* D24, H25, H32, O23, O47.

*For helpful comments, we thank Anmol Bhandari, David Bradley, Gabriela Cugat, Keyvan Eslami, Carlos Esquivel, Salomón García, Rafael R. Guthmann, Kyle Herkenhoff, Loukas Karabarbounis, Pete Klenow, Ben Malin, Ellen McGrattan, Jim Schmitz,Venky Venkateswaran, and participants of the Quantitative Macro Workshop at the University of Minnesota. The views expressed herein are those of the authors and not necessarily those of the Penn Wharton Budget Model or the World Bank Group. All mistakes are our own. Marcos Dinerstein is the corresponding author.

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1 Introduction

Corporate tax regulation generates heterogeneity in the effective tax rates faced by firms due to exemptions, deductions, and deferrals. At the same time, there is a large amount of dispersion in firm-level revenue productivity even within narrowly defined industries. This suggests that effective corporate tax rates can potentially generate an inefficient allocation of resources across firms by directly impacting revenue productivity. An inefficient allocation of resources will have a direct negative effect on total factor productivity (TFP).

This paper quantifies the effect of effective corporate tax rates on aggregate TFP through allocative efficiency. First, we use Chilean manufacturing census data for the years 1998 to 2007 and document several characteristics of the effective tax rate distribution. Two important findings are a large dispersion in the effective tax rate faced by firms and a mass of firms with a 0 percent tax rate. Next, we incorporate these features into a standard monopolistic competition model with capital and output wedges, where firms endogenously choose the tax rate they face. We then calibrate the model and find that if there were no corporate taxes in the economy, TFP would increase between 4 and 11 percent. Afterward, we study the effects of imposing the same tax rate on all firms, which we call a flat tax rate policy. We find a monotonically decreasing relationship between the level of the flat tax rate and TFP.

To carry out our analysis, we use the ENIA (Encuesta Nacional Industrial Anual), a plant-level manufacturing census from Chile that covers all establishments with more than 10 employees, for the time period 1998-2007.[1] The data set is an unbalanced panel that contains detailed balance sheet and production information. Importantly, it specifies net after-tax firm income and corporate taxes paid by firms. We use these two variables to construct the average effective tax rates faced by firms, which is essential for our analysis. The advantage of this effective tax rate measure is that it summarizes all the subtleties of the tax code into one measure. One drawback is that there may

1. Different years of this data set have been used in several well-known studies, such as Liu (1993), Levinsohn and Petrin (2003), Oberfield (2013), Petrin and Sivadasan (2013), and Asker, Collard-Wexler, and De Loecker (2014).

be endogeneity between firm choices and characteristics and the firm specific tax rate. We perform several exercises to address this drawback and find that our results do not change.

To study the impact of firm-specific corporate tax rates on TFP, we develop a small open economy model where firms are heterogeneous in their productivity. Firms can choose whether to face a positive exogenous tax and have non-negative accounting profits or face a 0 percent tax and have non-positive accounting profits. This feature incorporates a specific exemption present in the Chilean tax code, which establishes that firms with non-positive profits face a corporate tax rate of 0 percent. This exemption is relevant since it affects around 20 percent of firms in our sample. By modeling this exemption, we intend to partially address the concern that firms' behavior can affect their effective tax rate. We also introduce firm-specific capital and output wedges to account for all other distortions and model misspecification. If we did not explicitly model the corporate tax rate, it would be accounted for by the capital and output wedges. By introducing it, we are stripping away its contribution to the wedges.

Using the data described above, we back out the capital and output wedges necessary to rationalize firms' observed choices of inputs. We then take these wedges as primitives and measure the change in aggregate output of implementing different flat tax policies relative to the observed tax policy. Last, we measure how much of this output change is generated by intrasectoral allocative efficiency, intersectoral reallocation of resources, and changes in the demand of resources. We define the contribution of intrasectoral allocative efficiency to the change in aggregate output as the TFP gap.

We find that if corporate taxes are removed, there is a positive TFP gap ranging from 4 to 11 percentage points, depending on the year analyzed. Moreover, this gap decreases monotonically with the level of the flat tax rate and becomes negative after a threshold that varies with the year. We conclude that as the tax level increases, more resources are going to less productive firms. We also find that the revenue-neutral flat tax policy generates small changes in TFP. The contribution to the change in aggregate output of the intersectoral component is small relative to the TFP gap in every year and policy analyzed. Last, we perform several robustness checks to reinforce our results.

Our paper contributes mostly to the misallocation literature pioneered by Hsieh and Klenow (2009) and Restuccia and Rogerson (2008). This stream of literature documents large differences in TFP through the resource allocation channel. Following the categorization proposed in the survey by Restuccia and Rogerson (2017), the literature has studied misallocation via two approaches. The direct approach selects a factor that can potentially cause misallocation and measures its effects on allocative efficiency and TFP. Examples of such factors are financial frictions, firing costs, and size-dependent policies. Examples of these studies are Midrigan and Xu (2014) and Gopinath et al. (2017). The quantitative impact of this factor on aggregate TFP varies depending on the study. For example, Midrigan and Xu (2014) find that the effect is at most 10 percent in South Korea. Gopinath et al. (2017) document an increase in capital misallocation in the south of Europe and find that financial frictions can explain this fact. The effect on TFP is around 3 percent. Another possible source of misallocation is firing costs. Hopenhayn and Rogerson (1993) find that imposing a one-year firing cost in the United States would lead to a 2 percent drop in TFP. This drop is due to the misallocation of labor across firms and changes in the establishment productivity distribution. We contribute to this literature by studying how the dispersion and level of corporate tax rates affect aggregate productivity. Moreover, we do this by using a direct measure of this friction. To the best of our knowledge, this is the first attempt to measure the effects of effective corporate tax rates on TFP through allocative efficiency at the firm level. The indirect approach tries to measure the net effect of all the possible factors that generate misallocation without specifying a definite source. One caveat with this approach is that any misspecification of the theoretical model used to measure misallocation can potentially overstate it. We combine these two approaches by identifying a specific factor of misallocation, effective corporate tax rates, while also accounting for all other possible latent factors that could generate misallocation or model misspecification. By taking this approach, we are able to study the effect of heterogeneous effective corporate tax rates while accounting for any other distortion or model misspecification.

A strand of the literature argues that the dispersion in marginal products is a reflection of specific characteristics of the economic environment. David, Hopenhayn, and Venkateswaran (2016) study how information frictions show up as dispersion in marginal products. In their framework, firms face imperfect information when they make their input decisions and find losses in aggregate productivity for the United States, China, and India. Other environment specifications that yield dispersion in marginal revenue products are adjustment costs of capital, multiple production technologies, and different demand specifications.[2] Although these restrictions could generate dispersion, they do not imply misallocation, as a benevolent planner would face these same physical constraints when allocating resources. In our study, we take these factors into account by allowing corporate tax rates to interact with firm-specific output and capital wedges. These wedges are a reduced form of controlling for all frictions and model misspecification not accounted for in our theoretical framework.

Finally, this paper contributes to the broad literature that studies the effects of effective corporate tax rates in macroeconomic aggregates. This literature mainly studies how corporate taxes affect investment and entrepreneurship. The general finding is that corporate taxation has significant adverse effects on both investment and entrepreneurship.[3] One study that analyzes the Chilean economy is Hsieh and Parker (2007). The authors argue that the main cause of the investment boom in Chile in the last part of the eighties and nineties was due to a tax reform from 1984 through 1986 that cut the tax rate of retained profits from 50 percent to 10 percent. While these papers focus on investment and growth, our analysis is on the allocative effects of corporate

2. Asker, Collard-Wexler, and De Loecker (2014) find that adjustment costs can generate dispersion in marginal revenue products. Rossbach and Asturias (2017) analyze the impact of multiple production technologies on the dispersion of marginal products using the same data set used in our analysis. Haltiwanger, Kulick, and Syverson (2018) analyze how different demand specifications can show up as dispersion in revenue TFP.

3. See Djankov et al. (2010) and the references within.

tax rates.

The remainder of the paper is organized as follows. In Section 2, we describe the data used and document facts on the effective corporate tax rate distribution in Chile. Section 3 describes the theoretical framework used in our analysis and specifies the calibration of parameters. We perform our quantitative analysis in Section 4. In Section 5 we perform sensitivity analysis on the parameters chosen. Section 6 deals with caveats that may arise from our measurement of firm-specific effective tax rates. Last, we make concluding remarks in Section 7.

2 Description of the Data

This section describes the data used in our paper and presents facts about the effective corporate tax rate distribution in Chile.

2.1 The Annual Census of the Chilean Manufacturing Sector: ENIA

The data used are taken from the ENIA (Encuesta Nacional Industrial Anual), an annual census of the Chilean manufacturing sector. This data set is an unbalanced panel that covers all manufacturing plants with more than 10 employees and plants with less than 10 employees that belong to firms with multiple establishments. We use data for the period 1998-2007, as there were no reforms to the Chilean tax code in this time frame, except for pre-stipulated increases in the statutory tax rate. For the years of our sample, the statutory tax rate increased from 15 percent to 17 percent. After 2007, the ENIA's panel structure is eliminated, so that firms cannot be identified across years. For this reason, we do not use data after 2007, as doing so would have limited some of our quantitative exercises.

Firm and plant level data are only available for 1996 (we do not sue this year since it cannot be linked as a panel with the rest or our data). In that year, more than 95% of firms where operating in single-plant establishments.

We will use the term plant and firm interchangeably.

The ENIA collects data on revenue, net accounting profit, profit tax, employment, wage bill, fixed assets, and industry among other variables useful for our quantitative analysis. Previous versions of this census have been used in many studies, given its rich plant-level data. In Chile, the manufacturing sector accounted for roughly 17 percent of value added and 14 percent of employment for the period 1998-2007. Further details on the construction and representativeness of our sample can be found in Section A of the appendix.

2.2 Profit Tax Rate Facts in Chile

In this section, we document relevant tax facts about Chile. In Chile, all firms are subject to the same statutory tax rate, regardless of their level of profits. The ENIA collects plant-level data on net accounting profits and profit tax expenses. Using these two variables, we calculate the effective tax rate that each firm faces in a given year, as the ratio between profit tax expenses and gross accounting profits.[4]

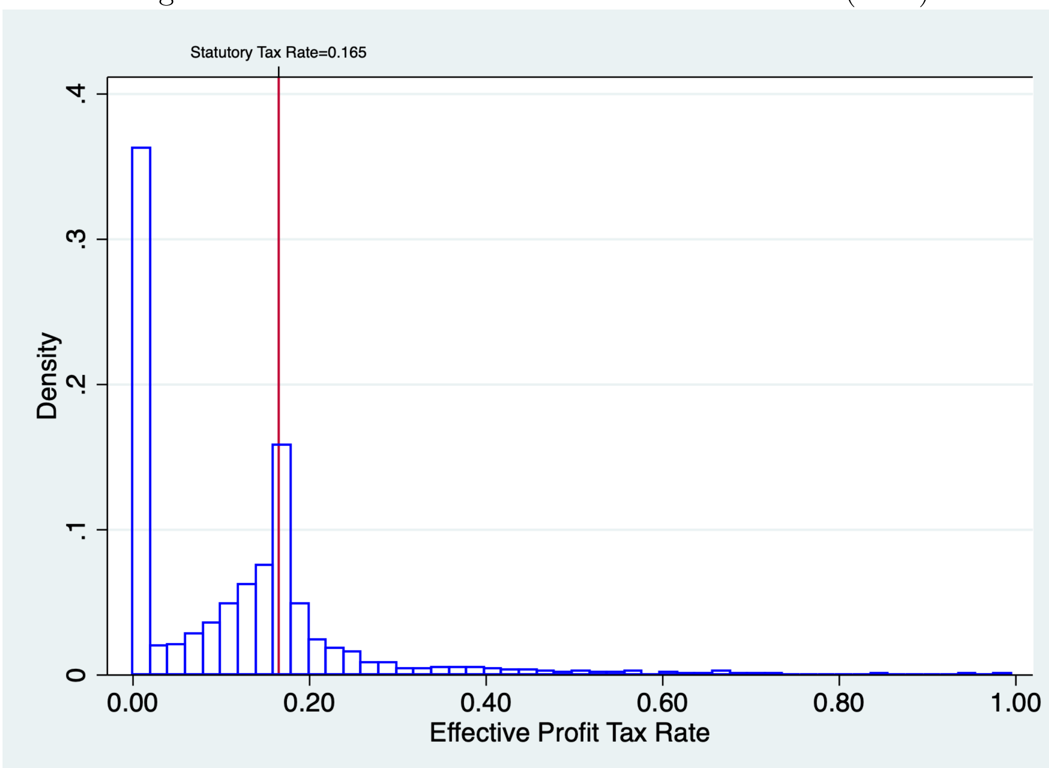
Figure 1 shows the distribution of effective profit tax rates for 2003, which we have used as an example year, as the distributions for all the years in our sample portray similar characteristics. In particular, four important features characterize the distributions of effective profit tax rates for each year in our time-window of analysis. First, a large number of firms face a 0 percent tax rate (close to 34 percent of firms in 2003). This feature is mainly driven by the tax code exemption that specifies that firms with non-positive accounting profits face a corporate tax rate equal to 0 percent.[5] Second, there is a large concentration of firms with effective tax rates around the statutory tax rate, as seen in Figure 1. Third, in Table 1 we document that close to 70 percent of plants have an effective tax rate below or equal to the statutory tax rate. Last, the effective profit tax rate that firms face has considerable dispersion,

4. Gross accounting profits is the sum of profit tax expenses and net accounting profits.

5. On average, 18 percent of the firms in our sample have non-positive profits. There are also some firms that have positive profits but 0 percent tax rate due to other exemptions in the tax code such as technology investment incentives.

as depicted in Figure 1 as well as the the last column of Table 1. Several exemptions outlined in the Chilean tax law, as well as fines for late payments and tax base revaluations to match economic activity with financial payments potentially generate dispersion in effective profit tax rates, as most firms have effective rates that differ from the statutory rate.

Figure 1: Distribution of Effective Profit Tax Rates (2003)



A plant may face an effective tax rate lower than the statutory tax rate because of loss carryforward, tax base revaluations, and other exemptions. Plants that face an effective tax rate that is higher than the statutory tax rate do so mainly for two reasons: late payment fines and tax base revaluations. Late payment fines range from 10 percent to 30 percent depending on how long it takes the plant to pay the amount owed. Plants also pay 1.5 percent interest per month on their debt. Taxes paid by tax base revaluations are technically called "deferred taxes". These tax base revaluations arise from analyzing the differences, mostly temporary, between taxable and accounting profit.

Table 1: Characteristics of Effective Profit Tax Rates

Year	Statutory Tax Rate (percent)	Tax Rate = 0 (percent of firms)	Tax Rate < Statutory (percent of firms)	St. Dev. (Percent)
1998	15	29.09	68.06	13.95
1999	15	33.24	67.66	13.90
2000	15	34.52	71.71	12.87
2001	15	38.21	72.40	12.79
2002	16	38.81	76.20	12.56
2003	16.5	34.04	71.81	13.44
2004	17	29.96	71.82	12.52
2005	17	28.89	71.26	12.86
2006	17	28.19	68.52	12.76
2007	17	30.44	69.89	13.19

The last column of Table 1 presents the standard deviation of effective corporate tax rates for every year of our sample. As mentioned previously, exemptions, deductions, and deferrals inherent to the Chilean tax code allow firms to have effective tax rates that are different than the statutory tax rate, resulting in dispersion in effective rates. To understand whether this dispersion is driven either by innate firm ability to utilize the tax code to reduce their tax burden over time (i.e. firm fixed effect), exemptions targeted at specific firm groups (i.e. region, industry, among others), or idiosyncratic variation, we carry out the following exercise. Using the unbalanced panel of firms between 1998 and 2007, we first regress effective profit tax rates on firm fixed effects and find that 41 percent of the variation in effective tax rates is explained by these fixed effects. Hence, a considerable fraction of the variation of effective profit tax rates is explained by firms' innate ability to use exemptions in the tax code in order to modify their tax base over time.

To determine whether the remaining variation in effective tax rates is a result of exemptions targeted at firms, at a very granular level, we then regress the residual effective tax rates (residuals of the first regression) on firm size, region, business entity type, and industry, including the interactions between these variables.[6] Table 8 in the appendix reports the R^2 of this exercise across years. Our results show that most of the dispersion in the residual effective profit tax rates is idiosyncratic as exemptions that are targeted according to size, region, entity type, industry, or firm clusters defined by combinations of these variables, explain only between 3 percent and 5 percent of the variation in residual effective tax rates.

3 Theoretical Framework

This section develops the theoretical framework that will allow us to evaluate the effect of corporate profit tax rates on resource allocations and its impact on TFP. We set up a standard monopolistic competition model with firm-specific output and capital wedges and firm-specific profit tax rates. We then explain the calibration of key parameters and the measurement of the variables that will be used in our quantitative analysis.

3.1 Monopolistic Competition Model

We consider a static monopolistic competition model with heterogeneous firms. We assume a small open economy where the world interest rate r is given and all changes in aggregate capital are due to inflows into the economy. Aggregate labor supply $\bar{L}$ is assumed to be inelastic. There is a single final good Y produced by a representative firm in a perfectly competitive output market. The representative firm's production function is a Cobb-Douglas aggregator,

6. We carry out three specifications as we consider three different firm size measures defined in terms of employment, sales, and value added, using the standard categorization of the ENIA. There are 9 groups for size in terms of employment and 10 groups size with respect to sales and value added. Also, firms are classified into 12 region groups and 8 types of business entities. Last, we group firms by two-digit industries according to the ISIC Rev. 3 industry classification.

and it uses output Y_s of industries $s \in \{1, ..., S\}$ as inputs:

$$Y = \prod_{s=1}^{S} Y_s^{\theta_s}, \quad \sum_{s=1}^{S} \theta_s = 1, \tag{1}$$

and P_s is the price of industry s.

Industry output is a CES aggregator of M_s differentiated products with elasticity parameter σ:

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

Differentiated product firms are heterogeneous in their physical productivity, A_{si}. Their production function is given by

$$Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}, \tag{3}$$

where K_{si} and L_{si} are the capital and labor inputs, respectively, and α_s is the capital share of industry s.

These firms maximize economic profit, which is the sum of accounting profit and the opportunity cost of capital. We make this distinction since corporate tax rates directly affect accounting profits. Note that in the data, a firm's tax rate is obtained as the product of the statutory tax rate and the tax base. A firm's tax base is a function of its accounting profits and the exemptions, deductions, and deferrals specified by the tax code. One exemption that we model explicitly is that firms with non-positive accounting profits face a 0 percent tax.

We model this exemption as follows. If a firm's accounting profit is non-negative, then the firm faces a profit tax rate, which we denote as t_{si}. This tax rate is exogenous and taken as given by the firm. On the other hand, if a firm has non-positive accounting profit, then its effective tax rate is equal to 0. Hence, a firm must choose whether to face a positive profit tax rate t_{si} and have non-negative accounting profit or a 0 profit tax rate with non-positive accounting profit.

Given this, the firm's problem is to maximize economic profit:

$$\pi_{si} = \max\left\{\pi_{si}^t,\ \pi_{si}^0\right\},$$

where π_{si}^t is the economic profit of a firm that faces profit tax rate t_{si}, conditioned on non-negative accounting profit, and π_{si}^0 is the economic profit of a firm that faces a profit tax of 0, conditioned on non-positive accounting profit. We express accounting profit as

$$\pi_{si}^A = P_{si}Y_{si} - wL_{si} - (\delta + \lambda r)\, K_{si} + \Gamma_{si}, \tag{4}$$

where δ is the depreciation rate, λ is the fraction of capital that is financed by debt and Γ_{si} is non-operational income net of non-operational costs.[7]

If a firm faces profit tax rate t_{si}, economic profit π_{si}^t is

$$\pi_{si}^t = \max_{\{K_{si}, L_{si}\}} \pi_{si}^A (1 - t_{si}) - \tilde{\tau}_{Ysi} P_{si} Y_{si} \quad - (1 - \lambda)\, rK_{si} - \tilde{\tau}_{Ksi}\, (r + \delta)\, K_{si}$$

$$\text{s.t.}\ \pi_{si}^A \geq 0 \ \ \left(\mu_{si}^t\right),$$

where μ_{si}^t is the Lagrange multiplier for the accounting profit's non-negativity constraint.

Maximization yields the following first-order conditions:

$$MRPK_{si} \equiv \alpha_s \frac{\sigma - 1}{\sigma} \frac{P_{si}Y_{si}}{K_{si}} = \frac{r\,(1 - \lambda t_{si} + \tilde{\tau}_{Ksi} + \lambda \mu_{si}^t) + \delta\,(1 - t_{si} + \tilde{\tau}_{Ksi} + \mu_{si}^t)}{1 - t_{si} - \tilde{\tau}_{Ysi} + \mu_{si}^t}, \tag{5}$$

$$MRPL_{si} \equiv (1 - \alpha_s)\, \frac{\sigma - 1}{\sigma} \frac{P_{si}Y_{si}}{L_{si}} = \frac{w\,(1 - t_{si} + \mu_{si}^t)}{1 - t_{si} - \tilde{\tau}_{Ysi} + \mu_{si}^t}. \tag{6}$$

7. The parameter λ is exogenous and constant across firms in our quantitative analysis and we set it equal to 0 in our baseline economy. Γ_{si} allows us to match accounting profits in the model to those in the data. We assume that it is firm specific and does not depend on the input choices of the firm.

If a firm faces profit tax rate 0, economic profit π^0_{si} is

$$\pi^0_{si} = \max_{\{K_{si},\, L_{si}\}} \pi^A_{si} - \tilde{\tau}_{Ysi} P_{si} Y_{si} \quad - (1-\lambda)\, r K_{si} - \tilde{\tau}_{Ksi} \,(r+\delta)\, K_{si}$$

$$\text{s.t.}\; \pi^A_{si} \leq 0 \;\; \left(\mu^0_{si}\right),$$

where μ^0_{si} is the Lagrange multiplier for the accounting profit's non-positivity constraint.

Maximization yields the following first-order conditions:

$$MRPK_{si} \equiv \alpha_s \frac{\sigma-1}{\sigma} \frac{P_{si} Y_{si}}{K_{si}} = \frac{r\,(1+\tilde{\tau}_{Ksi} - \lambda \mu^0_{si}) + \delta\,(1+\tilde{\tau}_{Ksi} - \mu^0_{si})}{1-\tilde{\tau}_{Ysi} - \mu^0_{si}}, \quad (7)$$

$$MRPL_{si} \equiv (1-\alpha_s) \frac{\sigma-1}{\sigma} \frac{P_{si} Y_{si}}{L_{si}} = \frac{w\,(1-\mu^0_{si})}{1-\tilde{\tau}_{Ysi} - \mu^0_{si}}. \quad (8)$$

Similar to Hsieh and Klenow (2009) and Foster, Haltiwanger, and Syverson (2008), we define revenue-based factor productivity as $TFPR_{si} \equiv P_{si} A_{si}$. Under a Cobb-Douglas production function, this can be expressed as

$$TFPR_{si} = \frac{\sigma}{\sigma-1} \left(\frac{MRPK_{si}}{\alpha_s}\right)^{\alpha_s} \left(\frac{MRPL_{si}}{1-\alpha_s}\right)^{1-\alpha_s}. \quad (9)$$

From equations (5)-(8), we observe that firms' marginal products differ when they face different wedges and profit tax rates. Importantly, we assume that tax rates do not affect capital and output wedges. However, the tax rate interacts with the wedges in the marginal products of the firm. If we were to set wedges and taxes to zero, then all firms would have the same marginal products. Given this, equation (9) shows that revenue productivity would also equalize across firms. On the contrary, when firms face different wedges and profit taxes, there is dispersion in revenue productivity. Furthermore, firms with higher $TFPR_{si}$ are those that have higher wedges, raising their marginal products and lowering their capital, labor, and output levels.

Using the above framework, we construct the aggregate measures for capital, labor, TFP, and output. First, we express the equilibrium allocations for sectoral resources, K_s and L_s, as

$$K_s = \sum_{i=1}^{M_s} K_{si} = K \cdot \omega_s^K, \tag{10}$$

$$L_s = \sum_{i=1}^{M_s} L_{si} = L \cdot \omega_s^L, \tag{11}$$

where $K = \sum_{s=1}^{S} K_s$ is aggregate capital, $L = \sum_{s=1}^{S} L_s$ is aggregate labor, ω_s^K is the sectoral share of capital, and ω_s^L is the sectoral share of labor. Sectoral shares have the following expression:

$$\omega_s^K = \frac{\alpha_s \theta_s / \overline{MRPK}_s}{\sum_{s'=1}^{S} \alpha_{s'} \theta_{s'} / \overline{MRPK}_{s'}} \tag{12}$$

$$\omega_s^L = \frac{(1-\alpha_s)\,\theta_s / \overline{MRPL}_s}{\sum_{s'=1}^{S} (1-\alpha_{s'})\,\theta_{s'} / \overline{MRPL}_{s'}}, \tag{13}$$

where $\overline{MRPK}_s$ and $\overline{MRPL}_s$ are the industry-weighted average of firms' marginal product of capital and marginal product of labor.

We derive industry productivity as

$$TFP_s \;\; = \;\; \left[\sum_{i=1}^{M_s} \left(A_{si} \frac{\overline{TFPR}_s}{TFPR_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}}, \tag{14}$$

where $\overline{TFPR}_s$ is the industry-weighted average of firms' revenue productivity.

Last, aggregate output can be expressed as a function of K_s, L_s, and TFP_s:

$$Y = \prod_{s=1}^{S} \left(TFP_s \cdot K_s^{\alpha_s} \cdot L_s^{(1-\alpha_s)} \right)^{\theta_s}. \tag{15}$$

3.2 Measurement and Calibration

We use the data described in Section 2.1 to calibrate the parameters of our model and measure firms' marginal revenue products and revenue productivities. Industries in the model correspond to the four-digit industries within the manufacturing sector according to the ISIC Rev. 3 industry classification.[8] We measure firms' value added, $P_{si}Y_{si}$, as the difference between gross revenue and intermediate inputs. We use four-digit industry deflators for gross revenue and intermediate inputs, provided by the data set, to deflate our estimate of firms' value added. Industry value added, P_sY_s, is measured as the sum of all firms' value added within industry s. The capital input, K_{si}, is measured as the book value of fixed assets, which we deflate using the gross revenue deflators. To control for differences in human capital, hour requirements, and rent sharing across plants, we follow Hsieh and Klenow (2009) and use the wage bill deflated by the intermediate input industry deflator as the measure for labor, L_{si}. In a robustness check, we also consider hours worked for our measure of labor.[9]

As described above, we calculate effective tax rates as the ratio between a firm's profit taxes and its gross accounting profits. We denote the measured firm-specific effective tax rate as $\hat{t}_{si}$. Two things should be noted. First, we use average effective tax rates as marginal effective tax rates. The main advantage of following this method is that all exemptions and deductions of the tax code are embedded in our measure. Hence, we do not have to model the intricate details of the tax code. The main drawback of our approach is that the observed tax rate is potentially endogenous to certain firms' characteristics and past behavior. We conduct several robustness checks to verify that our results are not driven by other specific characteristics and behavior of the firm.

We set the rental rate of capital to $r = 0.05$ and the depreciation rate to $\delta = 0.05$, to make our results comparable with Hsieh and Klenow (2009). The elasticity of substitution between varieties is fixed at $\sigma = 3$, so that firms'

8. The number of four-digit industries ranges from 80 and 85 depending on the year analyzed.

9. Due to data availability, we only carry out this analysis for the period 2001-2007.

price is 50 percent higher than their marginal cost. In Section 5.1, we evaluate the sensitivity of our results with respect to these assumptions. The capital share α_s in industry s is equal to 1 minus the labor share in that corresponding industry for the United States.[10] These shares are obtained from the NBER Productivity Database.[11]

Using the data and parameter values described above, we back out the capital and output wedges in the following manner. For firms with positive accounting profits, we use equations (5) and (6) to obtain the firm-specific wedges. Since $\mu_{si}^{t} = 0$, the output and capital wedges are

$$(1+\tau_{Ksi}) = \frac{\alpha_s}{(1-\alpha_s)} \frac{wL_{si}}{(r+\delta) K_{si}} \left(1-\hat{t}_{si}\right) + \frac{(\delta+\lambda r)\left(\hat{t}_{si}\right)}{(r+\delta)}, \tag{16}$$

$$(1-\tau_{Ysi}) = \frac{\sigma}{\sigma-1} \frac{wL_{si}}{(1-\alpha_s) P_{si} Y_{si}} \left(1-\hat{t}_{si}\right) + \hat{t}_{si}. \tag{17}$$

On the other hand, for firms with negative accounting profits the capital and output wedges are obtained from equations (7) and (8). In this case, $\mu_{si}^{0} = 0$ and the wedges are[12]

10. Following Hsieh and Klenow (2009), we set the capital shares for each industry equal to those of the United States as we suppose that the US economy is less distorted than Chile's economy.

11. Most data on firm labor payments do not include labor benefits such as social security contributions. In the same manner as Hsieh and Klenow (2009), we scale each industry's labor share by 3/2.

12. We cannot identify the capital and output wedges for firms that have accounting profits equal to 0, as we do not observe μ_{si}^{0} in the data. We assume these firms face a tax rate of 0 and use equations (18) and (19) to back out the wedges. Although these wedges are mismeasured, this assumption only ameliorates the impact of corporate tax rates on resource allocation, as it gives more explanatory power to the output and capital wedges. Hence, our measure of the impact of effective tax rates on allocative efficiency is conservative. Firms with gross accounting profits equal to 0 only represent between 2 and 8 percent of the sample for the period analyzed. There are between 10 to 16 percent firms with strictly negative profits depending on the period analyzed.

$$(1+\tau_{Ksi}) = \frac{\alpha_s}{(1-\alpha_s)} \frac{wL_{si}}{(r+\delta)\,K_{si}}, \tag{18}$$

$$(1-\tau_{Ysi}) = \frac{\sigma}{\sigma-1} \frac{wL_{si}}{(1-\alpha_s)\,P_{si}Y_{si}}. \tag{19}$$

Last, we use equations (3) and (9) to calculate firms' physical productivity, A_{si}, and revenue productivity, $TFPR_{si}$, respectively. Using equations (10)-(15), we construct industry and aggregate measures of output, productivity, capital, and labor.

4 Misallocation and Corporate Taxes

In this section, we use the framework developed above to analyze the impact of effective tax rates on allocative efficiency. First, we define the output gap as the change in output between two economies characterized by different wedges and tax policy, but holding the distribution of firm productivities constant. Then, we consider counterfactual tax policies and measure the implied output gap relative to the observed distribution of tax rates. We decompose this measure to analyze the effect on allocative efficiency of the observed effective tax rates. Finally, we analyze what happens with government revenue in our different counterfactuals. p[;

4.1 Output Gap Decomposition

To study the impact of different tax policies, it is convenient to define the output gap between two economies that only differ in the wedges and effective tax rates each firm faces. We decompose this gap into five objects: the TFP gap, intersectoral capital reallocation, intersectoral labor reallocation, change in aggregate capital, and change in aggregate labor. The TFP gap reflects intrasectoral reallocation, as can be seen from equations (9) and (14). Capital and labor intersectoral reallocation are also affected by tax rates and wedges since the industry shares of capital and labor, ω^K and ω^L, are a function of firms' marginal products. Aggregate capital demand changes for different tax rates and wedges through the marginal cost of capital. Last, in equilibrium aggregate labor demand equates aggregate labor supply, and given that aggregate labor supply is fixed, the change in aggregate labor is always zero between any two economies that differ in firm wedges and firm effective tax rates.

Consider two economies that have different firm-specific output and capital wedges and profit tax rates but are equal in all other aspects. Denote the levels of output of these two economies by Y and $\tilde{Y}$. We refer to the output gap as the log percentage difference between these two levels of output. Using equations (10), (11), and (15), the output gap can be decomposed as follows:

$$\underbrace{log\left(\frac{Y}{\tilde{Y}}\right)}_{Output\ Gap} = \underbrace{\sum_{s=1}^{S}\theta_s log\left(\frac{TFP_s}{T\tilde{F}P_s}\right)}_{TFP\ Gap} + \underbrace{\sum_{s=1}^{S}\alpha_s\theta_s log\left(\frac{\omega_s^K}{\tilde{\omega}_s^K}\right)}_{Intersectoral\ Capital\ Reallocation} + \underbrace{\sum_{s=1}^{S}(1-\alpha_s)\,\theta_s log\left(\frac{\omega_s^L}{\tilde{\omega}_s^L}\right)}_{Intersectoral\ Labor\ Reallocation}$$
$$+ \underbrace{\sum_{s=1}^{S}\alpha_s\theta_s log\left(\frac{K}{\tilde{K}}\right)}_{Change\ in\ Aggregate\ Capital} + \underbrace{\sum_{s=1}^{S}(1-\alpha_s)\,\theta_s log\left(\frac{L}{\tilde{L}}\right)}_{Change\ in\ Aggregate\ Labor}. \tag{20}$$

Below, we analyze different counterfactual tax rates policies and compare them to the distribution of tax rates observed in the data.

4.2 Output Gap Decomposition and Corporate Taxes

In this section, we quantify the output gap decomposition using equation (20). We consider two economies that differ only in the tax policy implemented. Both economies are subject to the same firm-specific output and capital wedges. By doing this, we ensure that firms face the same frictions and model misspecification implied by the data in both economies. In one economy, we set taxes to $t_{si} = 0$, and in the other economy, we set taxes to the observed firm-specific profit tax rates, $t_{si} = \hat{t}_{si}$. This measures the change in output implied by modifying the actual Chilean tax policy to one with no corporate taxation, allowing us to quantify the effect of the dispersion and level of the observed tax rates on TFP.

Table 2 presents the results from the output gap decomposition. Moving to a counterfactual scenario with no corporate tax rates generates an increase in output that ranges from 20 percent to 38 percent, depending on the year considered. In all of the years analyzed, TFP increases due to the policy change. This increase ranges from 4 percent to 11 percent and is due to a more efficient intrasectoral allocation of resources. The effect on intersectoral reallocation is small. Intersectoral allocation of capital accounts for between -3 percent and 2 percent of the change in output. In three years, the effect of intersectoral allocation of capital is negative. Intersectoral allocation of labor increases in all years but only between 0 percent and 2 percent. Most of the change in the output gap is generated by large increases in the demand for aggregate capital. This is an implication of the small open economy assumption of the model. Setting $t_{si} = 0$ directly changes the cost of capital, which in this case generates large inflows of capital into the economy. Last, since aggregate labor supply is inelastic, the change in aggregate labor is always zero for any counterfactual policy scenario. Hence, we do not report this change in Table 2.

Table 2: Output gap decomposition: $t_{si} = 0$ (percent)

Year	Output Gap	TFP Gap	Intersectoral K	Intersectoral L	ΔAggregate Capital
1998	20.00	5.47	1.32	1.38	11.82
1999	21.20	6.43	0.41	1.05	13.31
2000	28.46	8.22	1.60	0.95	17.69
2001	22.79	5.64	0.10	0.72	16.33
2002	19.60	4.52	0.61	0.34	14.14
2003	19.85	4.82	0.03	0.55	14.45
2004	22.30	4.16	-0.41	0.80	17.75
2005	31.20	4.33	-2.94	1.74	28.07
2006	35.29	6.83	0.06	1.53	26.86
2007	38.02	11.12	-0.55	1.31	26.14

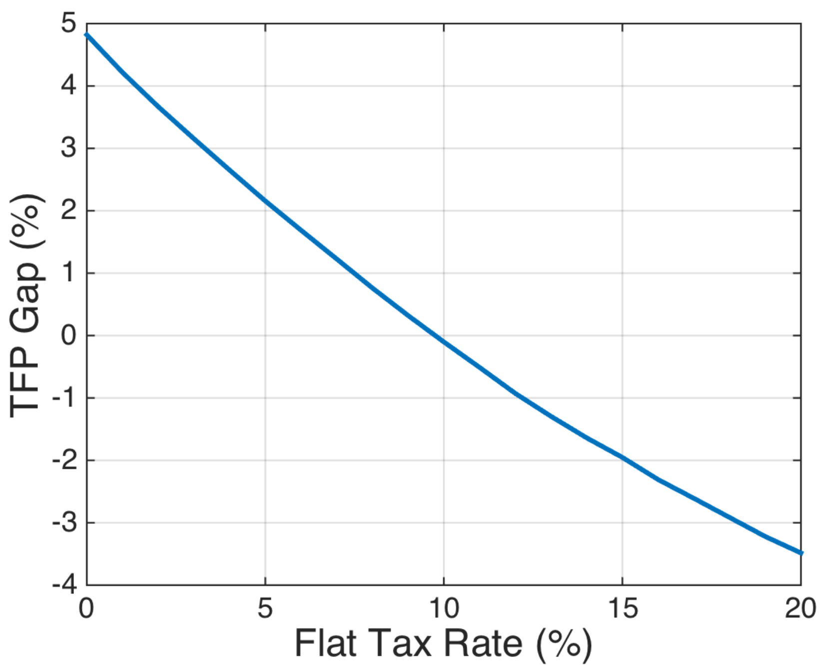
Notes: Since aggregate labor supply is inelastic, ΔAggregate Labor=0 for any counterfactual policy scenario.

4.3 Allocative Efficiency and Corporate Tax Rates

In this section, we analyze how different levels of tax rates affect our economy by considering different counterfactual flat tax rate policies. The equations implied by the model portray the mechanisms through which intrasectoral reallocation of resources occurs due to different tax policies. Profit tax rates affect firms' marginal products, as can be seen from equations (5)-(8). Since profit tax rates interact with firm-level wedges, flat tax rate policies will have heterogeneous effects.

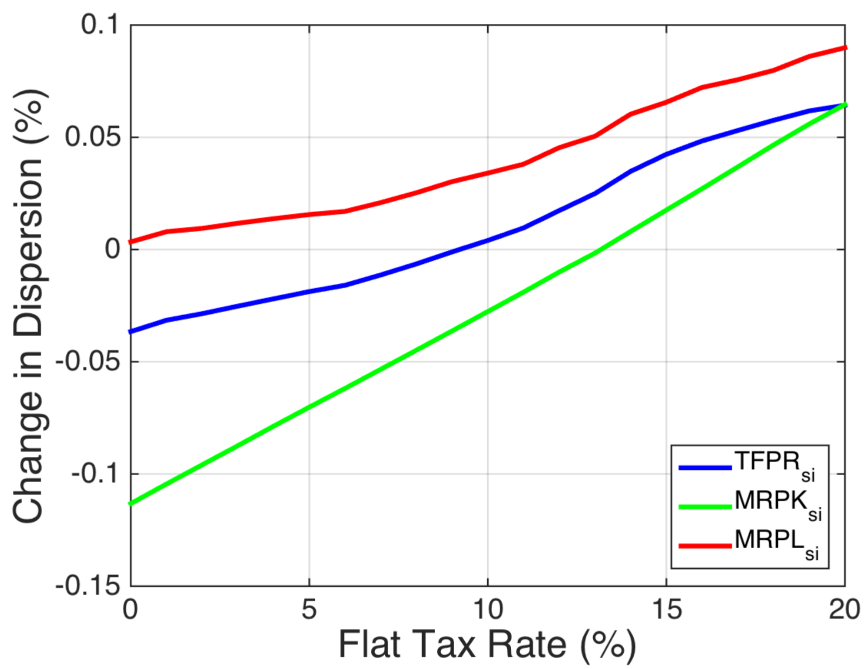
Our counterfactual exercise is the following. We set the corporate tax rate equal to $\bar{t}$ for all firms (i.e., $t_{si} = \bar{t} \ \forall i$). In these counterfactual scenarios, all firms face the same output and capital wedges implied by the data as well as a flat tax rate $\bar{t}$. We compare these counterfactual economies to the observed Chilean economy and measure changes in allocative efficiency with respect to the data.

Figure 2: Relationship between TFP Gap and $\bar{t}$ (2003)



The schedule in Figure 2 portrays the TFP gap between a counterfactual scenario with $t_{si} = \bar{t}$ and the observed Chilean economy $t_{si} = \hat{t}_{si}$, for different levels of $\bar{t}$, in the year 2003. This graph shows that the TFP gap decreases monotonically with the level of the tax rate, $\bar{t}$. This is the case for all the years studied in our sample. Furthermore, for lower levels of $\bar{t}$, the TFP gap is positive (TFP gains), while for higher levels of $\bar{t}$, this TFP gap becomes negative (TFP loss). In 2003, a flat tax rate policy of $\bar{t} = 0.0976$ would have generated the same aggregate TFP level as the one implied by the observed firm-specific corporate tax rates. This flat tax rate is lower than 16.5 percent, which was the statutory tax rate for that year. If in 2003 Chile had applied a flat tax rate policy at the statutory tax rate level without any exemptions and distortions, the loss in TFP would have been 2.46 percent. This remark is consistent for all the years in our sample.

Figure 3: Change in Dispersion Measures Relative to $\bar{t}$ (2003)



Notes: The change in dispersion for revenue productivity is measured as the log difference between the standard deviation of revenue productivity implied by the flat tax rate policy and the standard deviation of revenue productivity implied by the observed tax rates. The same statistic is calculated for marginal revenue products.

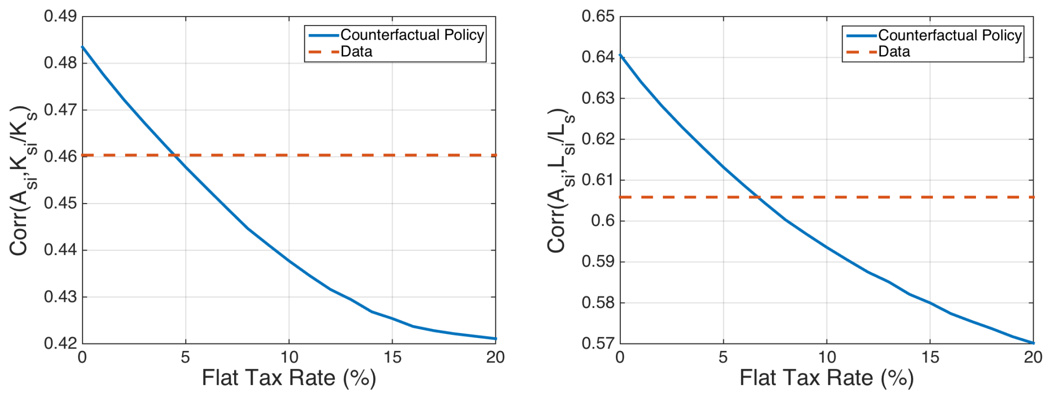
The monotonically decreasing relationship between the level of flat tax rates and the TFP gap can be explained as follows. For very small levels of flat tax rates, the dispersion in firms' marginal products and, hence, revenue productivity is lower. This has clear implications for aggregate TFP, as less dispersion in revenue productivity results in higher TFP. We can observe this mechanism in Figure 3, which shows the dispersion in marginal products and revenue productivity for counterfactual policy scenarios $t_{si} = \bar{t}$ relative to the dispersion in these measures in the data. As the level of the tax rate increases, the relative dispersion increases for both marginal products and revenue productivity. Intuitively, as the level increases, the profit tax rate amplifies the effects of the distortions and misspecification embedded in the output and capital wedges. As a result, dispersion in marginal products and revenue productivity increases, generating a lower TFP gap. This is the result of resources being allocated toward less productive firms within a sector.[13]

To corroborate our results, we perform an alternative measure of allocative efficiency similar to Olley and Pakes (1996). Our results are summarized in Figure 4. In Panel (a), the schedule labeled "Counterfactual Policy" plots the correlation between firm productivity, A_{si}, and the share of firm i's capital stock, K_{si}, in sector s's capital stock, K_s, for different flat tax rate levels $\bar{t}$. Panel (b) plots the correlation between firm productivity, A_{si}, and the share of firm i's labor, L_{si}, in sector s's labor, L_s, for different flat tax rate levels $\bar{t}$. The dotted line labeled "Data" corresponds to the correlation measures for the observed Chilean data in 2003. The correlation of firm productivity with respect to both capital and labor share drops as flat tax levels increase, which shows that the intrasectoral reallocation mechanism described above drives the fall in the TFP gap. More resources are being allocated toward less productive firms.

13. As a robustness check, we measure misallocation as in Olley and Pakes (1996) using our model outcomes. We find that the correlation of firm productivity with respect to both capital and labor shares within a sector drops as the tax levels increase.

Figure 4: Correlation between Firm Productivity and Activity Share (2003)

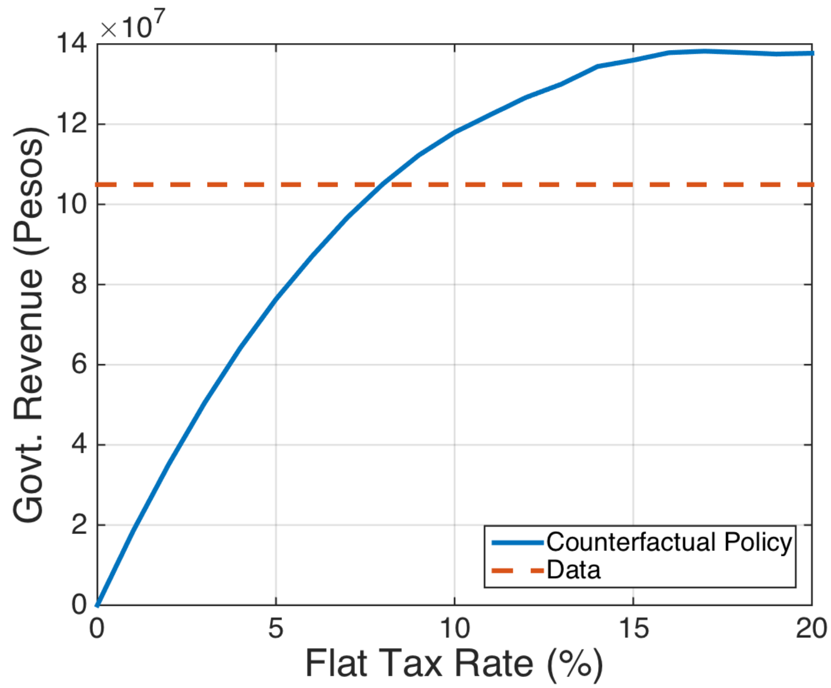
(a) Capital **(b) Labor**



Notes: The solid blue line labeled "Counterfactual Policy" corresponds to the correlation between firm productivity and firm activity share for different levels of $\bar{t}$. The dotted orange line labeled "Data" corresponds to the correlation between firm productivity and firm activity share in the data.

Next, we analyze the effect of these tax policies on government revenue. In Figure 5, the blue schedule labeled "Counterfactual Policy" portrays the Laffer curve for different flat tax rate policies. A clear trade-off stands out. Although very low flat tax rates yield higher levels of TFP, government revenue from corporate taxation is smaller. The dotted line labeled "Data" is the government revenue collected from the observed corporate tax rates. The flat tax rate policy that yields the same revenue is $\bar{t} = 7.97$ percent. If this policy had been implemented in Chile in 2003, then TFP would have increased by 0.77 percent. This pattern, however, is not found for all years in our sample. For some years in our sample, the revenue-neutral flat tax rate policy generates TFP gains with respect to the data, while for others it generates TFP losses.

Figure 5: Relationship between Government Revenue and $\bar{t}$ (2003)



Notes: The solid blue line labeled "Counterfactual Policy" corresponds to the government revenue for different levels of $\bar{t}$. The dotted orange line labeled "Data" corresponds to the government revenue implied by the observed effective tax rates.

5 Sensitivity Analysis

In this section, we analyze the sensitivity of the results in Section 4 to our choice of parameter values and our measure of labor input.

5.1 Sensitivity to Parameter Values

Table 3 shows the TFP gap from eliminating corporate taxes for different interest rates r, depreciation rates δ, and values of σ, the parameter of the elasticity of substitution across varieties. For different interest rates, results are identical to the benchmark. As seen in equation (4), when $\lambda = 0$, the interest rate r does not affect the accounting profits of firms. Hence, it does not interact with the corporate tax rate in the marginal revenue products, as shown in equations (5)-(8). For this reason, different interest rates do not affect the TFP gap when corporate tax rates are eliminated. This is not the case anymore when we consider different values of λ.

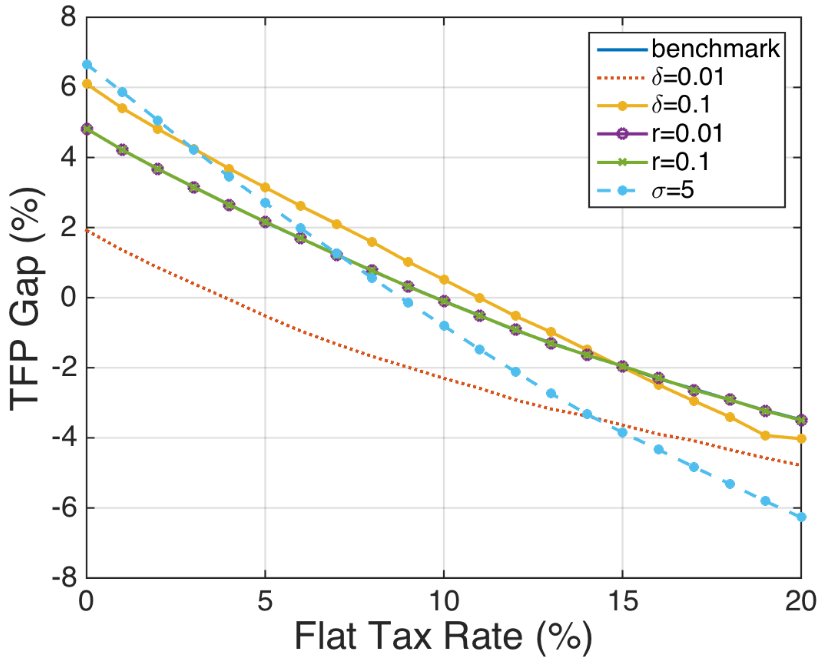
Table 3: TFP Gap for Different Parameter Values: $t_{si} = 0$ (percent)

Year	Benchmark	$r = 0.01$	$r = 0.1$	$\delta = 0.01$	$\delta = 0.1$	$\sigma = 5$
1998	5.47	5.47	5.47	4.26	5.92	11.04
1999	6.43	6.43	6.43	0.93	7.90	11.43
2000	8.22	8.22	8.22	5.37	9.48	15.74
2001	5.64	5.64	5.64	0.86	7.49	9.98
2002	4.52	4.52	4.52	1.46	5.62	8.00
2003	4.82	4.82	4.82	1.92	6.10	6.66
2004	4.16	4.16	4.16	0.92	6.15	7.42
2005	4.33	4.33	4.33	-4.08	7.48	6.52
2006	6.83	6.83	6.83	2.32	8.52	10.08
2007	11.12	11.12	11.12	7.75	12.56	16.73

On the other hand, the depreciation rate has a direct impact on accounting profits, regardless of the value of λ. Moreover, as the depreciation rate increases, the TFP gains from eliminating corporate taxes are higher. Finally, we have chosen a conservative σ at the low end of the empirical estimates. Under $\sigma = 5$, the TFP gains are higher from moving from the observed corporate tax rates to a counterfactual scenario with no corporate taxation.

As in Section 4.3, we carry out the same flat tax rate policy counterfactuals. Our results are robust when we consider different parameter values for r, δ, and σ. Figure 6 shows the same decreasing relationship between the TFP gap the level of the tax rate, $\bar{t}$, as the one found in Figure 2.

Figure 6: Relationship between TFP gap and $\bar{t}$: Parameter Sensitivity (2003)

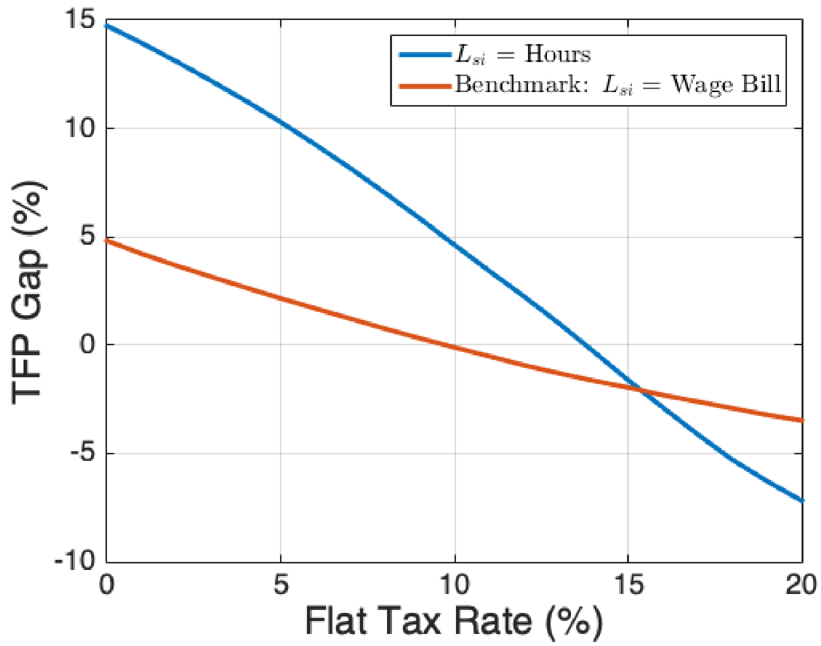


5.2 Hours Worked as Input for Labor

In the results described above, we measure L_{si} as the firm's wage bill. As a robustness check, we recalculate our estimates using hours worked as labor input.[14] Similar to Hsieh and Klenow (2009), using the wage bill for the labor input allows us to control for between-firm heterogeneity in rent sharing, skill level, and hours worked requirements. As these differences are not modeled in our framework, when we use hours as labor input, they are loaded into the output and capital wedges. As a result, dispersion in $TFPR_{si}$ is higher.

14. The data set analyzed has hours worked only for the years 2001-2007.

Figure 7: Relationship between TFP Gap and $\bar{t}$: Hours as Labor Input (2003)



Notes: Benchmark corresponds to the results of Figure 2.

Repeating our exercise with hours as labor input yields two main findings. First, in line with the results in Section 4.3, the TFP gap falls when we increase the level of the corporate tax rate, as seen in Figure 7. Second, the TFP gap across different counterfactual policies is larger. This is because our results are amplified since the corporate tax rate interacts with output and capital wedges, which are more dispersed for the reasons mentioned at the beginning of this section. This result holds across all years of our sample, as seen in the output gap decomposition in Table 9 in the appendix.

6 Robustness Checks on the Measurement of Effective Tax Rates

Given that we use average tax rates in our analysis, there is concern about the endogeneity of firms' characteristics and choices with our measure of the observed profit tax rate. To address this concern, we conduct several robustness checks. First, we analyze what would happen if all capital was financed with debt, which would change the financing structure of the firm and lower accounting profits, since interest can be subtracted. Second, we address the issue of loss carryforward by firms, which could explain our results since we are considering a static model. Third, we repeat our analysis with the permanent sample of firms. By doing this, we discard the possibility that special tax incentives of young or old firms may be driving our results. As shown below, we find that our results do not vary when taking these issues into account.

6.1 Financing Capital with Debt

So far, we have assumed that capital is financed entirely with equity, $\lambda = 0$. This is a strong assumption since firms may finance capital with a mix of capital and debt. Firms have incentives to finance capital with debt since interest payments are discounted from accounting profits and therefore lower the tax that firms must pay. In this section, we analyze the other extreme case in which all capital is financed with debt $\lambda = 1$ to determine whether our results are sensitive to this assumption. Note that our calculation of the effective tax rate that firms face is not affected by the capital structure decision of the firm since we observe profits net of interest and taxes. Hence, the tax rate we calculate already takes into account the firm's capital structure. However, our results will vary depending on the amount of capital a firm finances with debt, since λ interacts with the effective tax rate t_{si} in the marginal revenue product of capital.

Note that if we observed profits before subtracting interest and taxes instead of using profits net of interest and taxes, differences in access to credit and other distortions that may affect the capital structure would also be loaded into the effective tax rate instead of the capital and output wedges. Also, it is important to note that the fraction of capital financed with debt can potentially be firm specific. For example, some firms may have better access to credit than others. Uras (2014) explores this mechanism and finds that it has important implications for capital misallocation. In our setup, these differences in access to credit are reflected in the capital and output wedges.

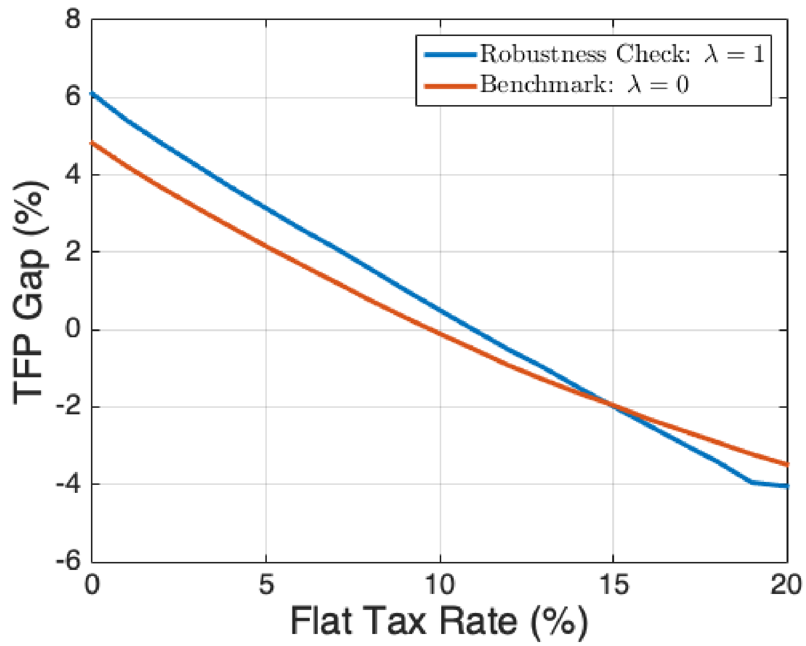
Table 4: Output gap decomposition: $\lambda = 1$, $t_{si} = 0$ (percent)

Year	Output Gap	TFP Gap	Intersectoral K	Intersectoral L	ΔAggregate Capital
1998	16.58	5.92	1.72	1.34	7.60
1999	17.51	7.90	1.31	1.00	7.30
2000	24.10	9.48	1.91	0.97	11.74
2001	18.75	7.49	0.85	0.71	9.70
2002	15.90	5.62	1.43	0.34	8.51
2003	16.79	6.10	1.13	0.52	9.03
2004	19.09	6.15	0.78	0.79	11.38
2005	26.57	7.48	0.16	1.68	17.26
2006	31.18	8.52	0.64	1.52	20.50
2007	34.54	12.56	0.58	1.29	20.11

Notes: Since aggregate labor supply is inelastic, ΔAggregate Labor=0 for any counterfactual policy scenario.

Table 4 shows the output gap decomposition under $\lambda = 1$ and under the scenario in which corporate tax rates are equal to $t_{si} = 0$. Results are very similar to those of Table 2. The increase in output from eliminating the effect of dispersion and level of corporate taxes is mainly explained by an increase in aggregate capital demand and an increase in TFP. Hence, we can see that intrasectoral reallocation of resources plays a significant role in explaining the output gap, while intersectoral reallocation of resources has a negligible effect on the output gap. This finding is consistent with the results found in Section 4.2.

Figure 8: Relationship between TFP Gap and $\bar{t}$: $\lambda = 1$ (2003)



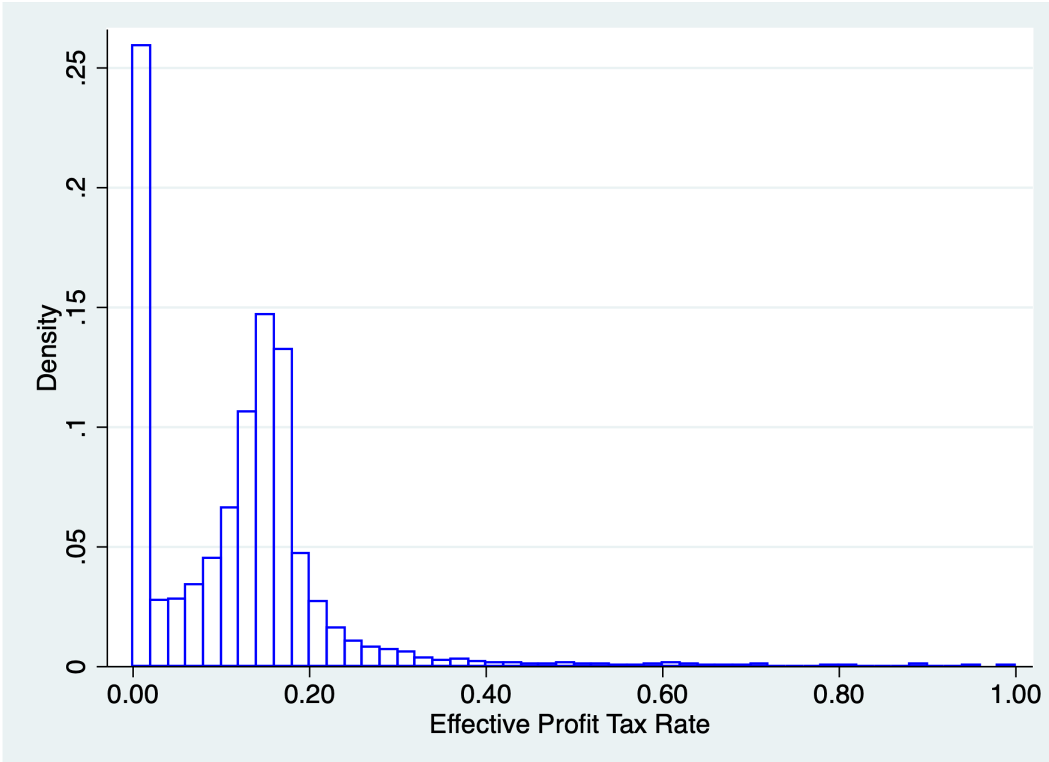
Notes: Benchmark corresponds to the results of Figure 2.

As in Section 4.3, we carry out different counterfactual flat tax rate policies and evaluate their relationship to the TFP gap. In Figure 8 we can observe that results are similar under the scenario in which all capital is financed by debt, $\lambda = 1$, and under the benchmark scenario in which capital is financed by equity, $\lambda = 0$. That is, as the flat tax rate level increases, the TFP gap falls. Also under the assumption that $\lambda = 1$, the dispersion of marginal products and revenue productivity increases as the flat tax rate levels increase. Higher flat tax rates exacerbate the effect of output and capital wedges, generating the increase in dispersion. Furthermore, as in Section 4.3, this increase in the dispersion of revenue productivity is a result of resources reallocating from more productive firms to less productive firms as the flat tax rate increases.

6.2 Accounting for Loss Carryforward

One of the exemptions that may generate dispersion in effective corporate tax rates is the fact that plants can carry forward losses from one period to the next to reduce their tax base. Our results in section 2.2 show that firm fixed effects account for a considerable fraction of the variation of effective corporate tax rates. Firm fixed effects capture plants' ability to utilize the tax code to the modify their tax base, through exemptions like loss carryforward. In particular, firms optimally choose capital and labor taking into account that this exemption allows them to reduce their tax burden. However, we do not model this explicitly since our analysis is static, and thus this specific source of distortion is loaded into the wedges. To measure how sensitive our results are to this omission, we consider the following exercise. We take the average across years for each plant's relevant variables and estimate the TFP gap for our policy counterfactuals. By doing this, any losses that could have been carried forward will smooth out. Note that if all the dispersion in effective tax rates was due to this channel, the tax rates that firms face in this exercise should be less dispersed and similar to the statutory rate. This is not the case, however, as the effective tax rate calculated by averaging profit and profit tax across years is distributed similarly to the effective tax rates calculated year by year. We can see this by comparing Figures 1 and 9.

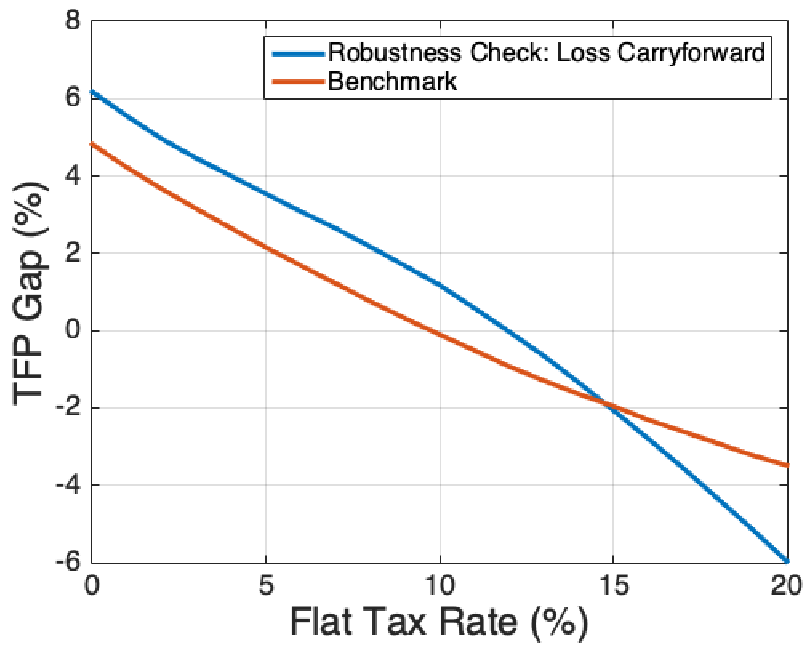
Figure 9: Distribution of Effective Profit Tax Rates - Loss Carryforward (2003)



Our results for this exercise are similar to our benchmark results. The decomposition of the output gap when firms face $t_{si} = 0$ can be seen in Table 10 in the appendix. When firms do not face corporate tax rates, TFP increases by 6.18 percent, which is within the range of values of our benchmark analysis, as seen in Table 2. Hence, loss carryforward is not the main driver of the distortions generated by heterogeneous tax rates. Similar to Section 4.2, intersectoral reallocation of resources accounts for a very small portion of the output gap, while changes in aggregate capital demand play a more significant role.

As in the benchmark, we also carry out flat tax rate counterfactual policies and measure their effect on aggregate TFP. We find that the negative relationship between the TFP gap and the flat tax rate level still persists, as seen in Figure 10. Hence, despite eliminating the dispersion in corporate tax rates coming from loss carryforward, as the flat tax rate increases, resources are reallocated from more efficient firms to less efficient firms.

Figure 10: Relationship between TFP Gap and $\bar{t}$: Loss Carryforward (2003)



Notes: Benchmark corresponds to the results of Figure 2.

6.3 Permanent Sample

Dispersion in corporate tax rates can potentially be driven by tax exemptions given to young entrant firms, which are usually directed at fostering industry competition. If this is the only source of tax rate dispersion and entrant firms are relatively less productive than incumbent firms, then these tax exemptions would be responsible for the positive TFP gap shown in Table 2. Intuitively, these tax exemptions would be allocating more resources to less productive entrant firms and fewer resources to more productive incumbent ones. Hence, if Chile moved to a tax policy with no corporate taxes, then resources would reallocate to the more productive incumbent firms, generating the positive TFP gap.

To control for this mechanism, we focus on the firms that were always in operation for the period 1998 to 2007 and then perform the output gap decomposition for the years 2003 to 2007. By doing this, we make sure that the firms had been in operation at least five years.[15] If the only source of tax rate dispersion was exemptions to less productive entrant firms, then when we eliminate them from the sample, the TFP gap would be 0. This is not the case, however, as can be seen in Table 5, which implies that there are other sources of corporate tax rate dispersion that generate a positive TFP gap. In this exercise, we also control for the fact that less productive exiting firms are driving our results, since the permanent sample comprises highly productive firms that have been operating for at least 10 years.

As shown in Table 11 in the appendix, there is significant dispersion in the effective corporate tax rates faced by the firms in the permanent sample for all years. Hence, tax exemptions given to young firms are not the main driver of this dispersion.

Table 5: Output Gap Decomposition: Permanent Sample, $t_{si} = 0$ (percent)

Year	Output Gap	TFP Gap	Intersectoral K	Intersectoral L	ΔAggregate Capital
2003	19.23	2.63	-0.08	0.75	15.98
2004	22.40	4.32	0.16	1.29	16.99
2005	22.96	3.54	-0.09	1.36	18.13
2006	27.75	4.74	-0.91	2.18	21.72
2007	26.36	5.36	-0.20	1.68	19.51

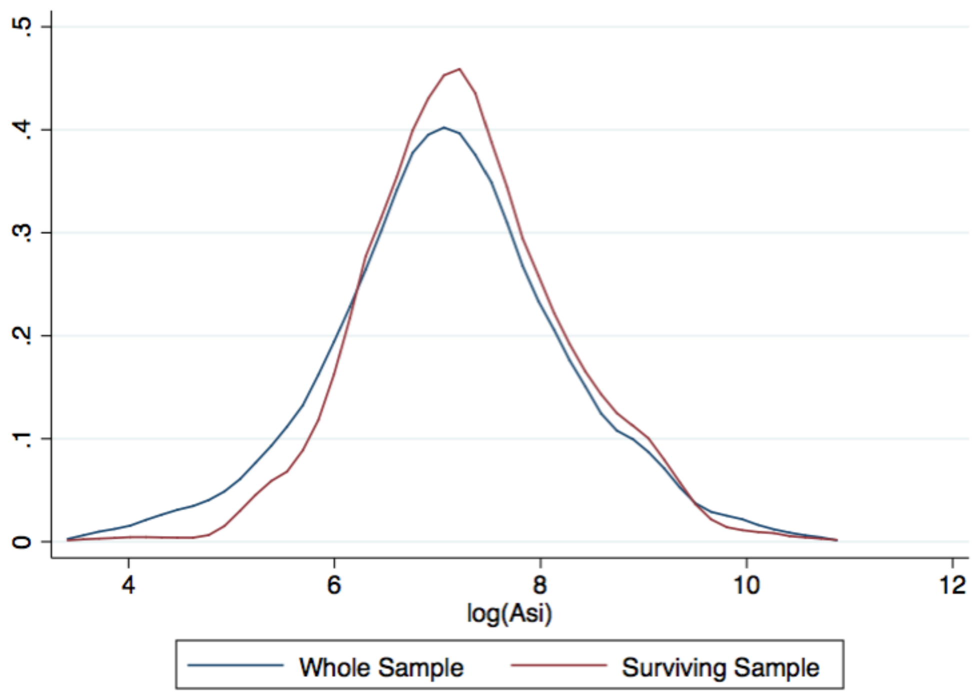
Notes: Since aggregate labor supply is inelastic, ΔAggregate Labor=0 for any counterfactual policy scenario.

By comparing Table 5 with Table 2, we can see that the results for intersectoral reallocation of resources and changes in input demands are similar. Also,

15. We also perform the analysis for the years 1998 to 2002, and the results are very similar.

we can observe that the TFP gap from eliminating corporate taxes is smaller in the permanent sample in comparison to the whole sample. The main reason for this finding is that the permanent sample controls for firm entry and exit. Firms in this sample had been in operation for at least 10 years in 2007. Hence, they were relatively more productive than the firms that entered or exited the sample during the time period we analyze. We document this finding in Figure 11, in which we compare the distribution of $\log(A_{si})$ for the whole sample in comparison to the permanent sample for 2003.

Figure 11: Distribution of $\log(A_{si})$ for the Whole and Permanent Samples



We find that the mean of $\log(A_{si})$ is higher in the permanent sample in comparison to the whole sample. Moreover, the distribution of the permanent sample has a much thinner left tail and is more concentrated around the mean. This pattern occurs in all the years between 1998 and 2007. This is evidence that the firms that exit every year tend to be the least productive firms, while the more productive firms remain. As a result, the gains from reallocation of resources in the permanent sample are smaller than in the whole sample.[16] Last, it is important to note that for the permanent sample, the TFP gap is also decreasing in the level of flat tax rates, as seen in Figure 12 in the appendix.

7 Conclusion

The objective of this paper is to quantify the effects of corporate tax rates on aggregate TFP through allocative efficiency. To do this, we set up a standard monopolistic competition model that includes firm-specific corporate tax rates as well as output and capital wedges. In our framework, firms can choose whether to face a positive tax rate and have non-negative accounting profits or face a tax rate of 0 percent and have non-positive accounting profits. We incorporate this exemption from the Chilean tax code to address the caveat that firms' behavior can affect the effective tax rate they face. We calibrate the model and find that if Chile had eliminated corporate tax rates, then TFP would have increased between 4 percent and 11 percent for the period 1998-2007. We also analyze how different levels of flat corporate tax rates affect TFP in an economy characterized by other distortions. We show that there is a monotonically decreasing relationship between the TFP gap and the level of the flat tax rate. We carry out a sensitivity analysis on parameters and robustness checks on our measure of effective tax rates and find that our results do not vary.

16. This finding is consistent with what Gopinath et al. (2017) find when analyzing Spanish firm-level data.

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A The Annual Census of the Chilean Manufacturing Sector

We use the manufacturing sector census data from Chile to construct our sample in the following manner. First, we drop all observations with negative values for output, capital, wage bill, and profit taxes. We believe these negative values are due to reporting error. Our model explains that aggregate TFP is affected by the dispersion of marginal revenue products. For this reason, we trim the 1 percent tails of the observations by the marginal revenue product of capital, $MRPK_{si}$, and the marginal revenue product of labor, $MRPL_{si}$. Then we eliminate the 0.5 percent tails of the observations by physical productivity, A_{si}. Last, when we consider counterfactual flat tax rate policies, there are cases in which some plants have marginal revenue products with negative values, a result that is mathematically possible but theoretically inconsistent. As a result, we eliminate observations with negative marginal revenue products for a counterfactual flat tax rate of 20 percent, which is the highest flat tax level we analyze. If a firm has positive marginal revenue products for this tax rate, then it also does for a lower flat tax rate. On average, the number of firms that are eliminated because of this criterion are only 1.7 percent of the total sample.

Table 6: Number of Plants and Shares in Total Plants by Size Class

Year	Number of Plants	0 - 9 employees	10 - 49 employees	50 - 199 employees	200+ employees
1998	4,530	0.02	0.65	0.25	0.08
1999	4,052	0.06	0.64	0.23	0.07
2000	3,998	0.07	0.64	0.22	0.07
2001	4,214	0.11	0.60	0.21	0.08
2002	4,576	0.11	0.61	0.21	0.07
2003	4,509	0.10	0.60	0.22	0.08
2004	4,726	0.09	0.61	0.22	0.08
2005	4,461	0.11	0.56	0.24	0.09
2006	4,183	0.11	0.55	0.25	0.09
2007	3,919	0.10	0.54	0.25	0.11

The total number of plants in our sample each year ranges between 3,919 and 4,726, as can be seen in Table 6. Between 1998 and 2007, plants with 10 to 49 workers accounted for 60 percent of the total number of establishments, on average. Plants with 0 to 9 workers, 50 to 199 workers, and 200+ workers had an average participation share in the total number of firms of 9 percent, 23 percent, and 8 percent, respectively.

Table 7 presents the representativeness of our sample with respect to the manufacturing sector by size category. For value added, the share of firms with more than 200 employees is 7 percentage points higher in the manufacturing sector than in our sample. On the contrary, this share is 6 percentage points lower in the manufacturing sector relative to our sample for firms with 50 to 199 employees. The representativeness of our sample is better across the three different size categories for employment and the wage bill.

Table 7: Shares of Total Manufacturing Economic Activity

By Size Category (Average for 1998-2007)

Economic Activity:	10 - 49 employees	50 - 199 employees	200+ employees
Share of Value Added:			
Sample	0.11	0.26	0.63
Manufacturing Sector	0.10	0.20	0.70
Share of Employment:			
Sample	0.19	0.30	0.51
Manufacturing Sector	0.18	0.28	0.54
Share of Wage Bill:			
Sample	0.14	0.29	0.57
Manufacturing Sector	0.12	0.26	0.62

Notes. This table only analyzes plants with more than 10 employees since those with less than 10 are underrepresented in the ENIA.

B Profit Tax Rate Facts in Chile

Table 8: Variation of Tax Rates Explained by Firm Group Exemptions (R^2)

Year	Size by Employment	Size by Sales	Size by Value Added
1998	0.0332	0.0460	0.0443
1999	0.0377	0.0397	0.0365
2000	0.0347	0.0329	0.0416
2001	0.0445	0.0450	0.0550
2002	0.0271	0.0299	0.0345
2003	0.0260	0.0354	0.0345
2004	0.0262	0.0422	0.0324
2005	0.0320	0.0320	0.0392
2006	0.0336	0.0445	0.0386
2007	0.0308	0.0503	0.0468

Notes. This table reports the R^2 for the regressions of residual effective tax rates on firm size, region, business entity type, and industry, as well as the interactions between them. Residual effective tax rates are the residuals of a regression of effective tax rates on firm fixed effects and year fixed effects. We use three different size variables, which are measured by employment, sales, and value added. The table reports results separately for each size variable. The groups for each size variable are based on a standard categorization by the ENIA. There are 9 groups for employment and 10 groups for sales and value added. Firms are classified into 12 region groups and 8 types of business entities. Last, we group firms by two-digit industries according to the ISIC Rev. 3 industry classification.

C Sensitivity Analysis

Table 9: Output gap decomposition: Hours as Labor Input, $t_{si} = 0$ (percent)

Year	Output Gap	TFP Gap	Intersectoral K	Intersectoral L	ΔAggregate Capital
2001	67.93	14.94	-2.50	2.10	53.38
2002	60.80	14.36	-0.81	1.98	45.32
2003	66.75	14.74	-1.78	3.10	50.71
2004	80.08	23.41	-3.88	3.21	57.39
2005	101.54	31.07	-3.95	2.36	72.02
2006	123.91	33.70	-1.40	13.15	78.42
2007	118.84	32.19	-4.47	4.97	86.14

D Robustness Checks on the Measurement of Effective Tax Rates

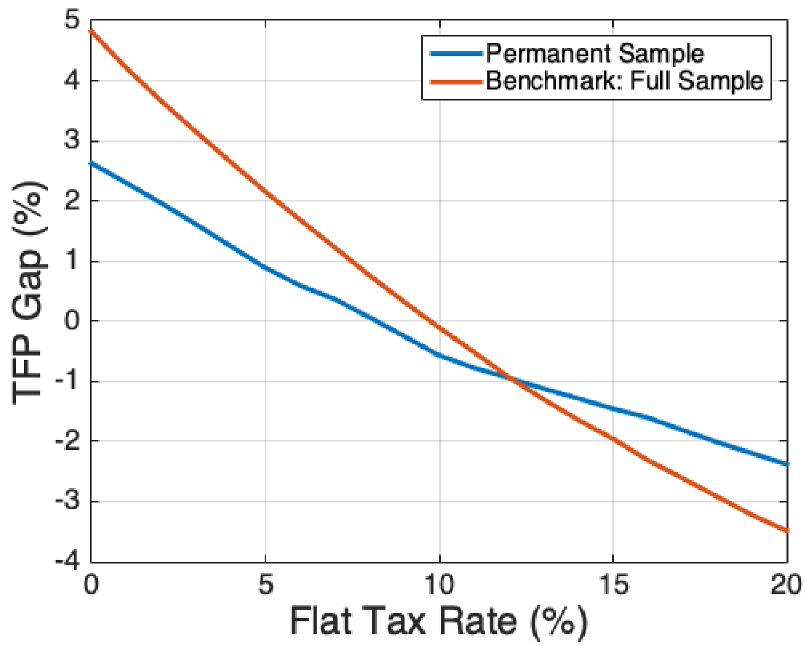
Table 10: Output gap decomposition: Loss Carryforward, $t_{si} = 0$ (percent)

Output Gap	TFP Gap	Intersectoral K	Intersectoral L	ΔAggregate Capital
22.99	6.18	0.78	0.74	15.30

Table 11: Characteristics of Effective Profit Tax Rates: Permanent Sample

Year	Statutory Tax Rate (percent)	Tax Rate = 0 (percent of firms)	Tax Rate < Statutory (percent of firms)	St. Dev. (Percent)
2003	16.5	22.91	65.17	12.53
2004	17	16.74	64.54	11.06
2005	17	16.84	64.75	11.52
2006	17	16.95	64.85	10.38
2007	17	18.51	63.39	13.05

Figure 12: Relationship between TFP Gap and $\bar{t}$: Permanent Sample (2003)



Notes: Benchmark corresponds to the results of Figure 2.