

# Essays on Government Policy and Productivity

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## **Dedication**

To my parents Horacio and Cecile Ann, my sister Gabriela, and my brother Jaime. Thank you for always being there for me.

## Abstract

This dissertation studies the effects of government policy on aggregate productivity by studying how government policy affects the allocation of resources across firms. Chapter 1 describes the data used in the following chapters. importantly, this data set is a plant level census of the manufacturing sector in Chile which allows to study government policy while taking into consideration firm heterogeneity.

Chapter 2 was written jointly with Fausto Patiño Peña. It quantifies the effect of effective corporate tax rates on aggregate TFP through allocative efficiency. First, using the data described in Chapter 1 for the years 1998 to 2007 several characteristics of the effective tax rate distribution are documented. 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, these features are incorporated into a standard monopolistic competition model with capital and output wedges, where firms endogenously choose the tax rate they face. The model is then calibrated and the main finding is that if there were no corporate taxes in the economy, TFP would increase between 4 and 11 percent. Afterward, the effects of imposing the same tax rate on all firms are studied. A monotonically decreasing relationship between the level of the flat tax rate and TFP is found.

Finally, Chapter 3 studies the interaction between financial frictions and firing costs and its effects on allocative efficiency and aggregate productivity. In particular, it quantifies the effect on aggregate productivity of an improvement in financial development in economies with firing costs. To do this, a small open economy model with heterogeneous firms that face collateral constraints and have to pay firing costs is developed. The model is then calibrated using the data described in Chapter 1. The main finding is that aggregate productivity increases by 2.5 percent following a financial reform that makes Chile's level of financial development comparable to that of the United Kingdom.

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# 1 Encuesta Industrial Nacional Anual: Plant Level Census Data from Chile

## 1.1 Introduction

This chapter describes the annual census of the Chilean manufacturing sector. This data set is used in the following chapters. Previous versions of this data set have been used extensively throughout different streams of economic literature.<sup>1</sup> This data set is very complete and has the potential to exploit different levels of firm heterogeneity and its effects on the economy as a whole. In this dissertation it is used to measure how different government policies affect the allocation of resources.

## 1.2 The Annual Census of the Chilean Manufacturing Sector: ENIA

The ENIA (Encuesta Nacional Industrial Anual) is 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. The current available version comprises the periods from 1995 to 2017. However, the data set only has a panel structure for the periods 1995 to 2007. After 2007 firms cannot be linked across time.

The ENIA collects data on revenue, net accounting profit, profit tax, employment, wage bill, fixed assets, hours worked classified by type of worker, severance payments for certain years, as well as other balance sheet variables. importantly, the data set has ISIC Rev 3.1 classification by industry up to the fourth digit and comes with a set of industry deflators both for gross revenue and intermediate inputs.

One of the main advantages of this data set is that it includes small firms as well as large firms and most firms are private. Table 1 shows the share of firms by plant size for selected years of the data set. The total number of plants ranges between 3,919 and 4,726. 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,

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<sup>1</sup>Different years of this data set have been used in several well-known studies, such as Liu (1993), Levinsohn and Petrin (2003), Oberfeld (2013), Petrin and Sivadasan (2011), and Asker et al. (2014).

23 percent, and 8 percent, respectively. It should be noted that plants with 0 to 9 workers are underrepresented in this data set since the only plants with 0 to 9 employees included are the ones that belong to firms with multiple establishments.

Table 1: 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

### 1.3 Conclusion

The ENIA is a very complete plant level data set that represents all plants in the manufacturing sector in Chile with more than ten employees. This makes it great tool to evaluate how government policy affects firms depending on their specific characteristics and quantify the impact of these changes on the aggregate economy. On the next two chapters, I use this data set to analyze fiscal policy, as well as labor and financial policies. More details of this data set will be added in the specific chapters below.

## 2 Corporate Tax Rates, Allocative Efficiency, and Aggregate Productivity

### 2.1 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 productivity even within narrowly defined industries. As a result, effective corporate tax rates can potentially generate an inefficient allocation of resources across firms, which directly affects total factor productivity (TFP).

This chapter 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.

The chapter 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. 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.

To carry out our analysis, we use the data set described in Chapter 1, for the time period 1998-2007. Importantly, this data set 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 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.

This chapter is related to an ongoing literature that tries to identify the main drivers of misallocation of resources and its effects on TFP.<sup>2</sup> One factor analyzed in many studies is financial development. 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.

A strand of the literature argues that the dispersion in marginal products is a reflection of specific characteristics of the economic environment. David et al. (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.<sup>3</sup> Although these restrictions

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<sup>2</sup>See Hopenhayn (2014) and Restuccia and Rogerson (2017) for a recent survey of this literature.

<sup>3</sup>Asker et al. (2014) find that adjustment costs can generate dispersion in marginal revenue products.

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 chapter 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.<sup>4</sup> 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 tax rates.

The remainder of the chapter is organized as follows. In section 2, we 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.

## 2.2 Profit Tax in Chile

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

### 2.2.1 Data

The data used is the one described in Chapter 1. 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. Table 2 shows the statutory tax rate for each year in

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Roszbach 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 et al. (2018) analyze how different demand specifications can show up as dispersion in revenue TFP.

<sup>4</sup>See Djankov et al. (2010) and the references within.

our sample. 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.

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.1 of the appendix.

### **2.2.2 Profit Tax 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.<sup>5</sup> For the years of our sample, the statutory tax rate increased from 15 percent to 17 percent. The effective profit tax rate that firms face has considerable dispersion, as seen in Table 2. This dispersion is generated by 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.

An important feature of the distribution of effective tax rates in Chile is that, on average, 30 percent of firms face a 0 percent tax rate. 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.<sup>6</sup> We also document that 75 percent of plants have an effective tax rate below or equal to the statutory tax rate, as can be seen in Table 2.

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.

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<sup>5</sup>Gross accounting profits is the sum of profit tax expenses and net accounting profits.

<sup>6</sup>On average, 18 percent of the firms in our sample have non-positive profits.

Table 2: Distribution of Effective Profit Tax Rates (percent)

Year	Statutory Tax Rate	25th percentile	50th percentile	75th percentile	90th percentile	Standard Deviation
1998	15	0	12.14	15.78	25.79	13.95
1999	15	0	12.03	15.63	24.81	13.90
2000	15	0	10.95	15.04	22.98	12.87
2001	15	0	9.69	15.01	22.06	12.79
2002	16	0	8.68	16.00	21.10	12.56
2003	16.5	0	11.31	16.58	23.19	13.44
2004	17	0	13.45	17.00	22.97	12.52
2005	17	0	14.08	17.02	22.76	12.86
2006	17	0	14.53	17.20	23.58	12.76
2007	17	0	13.99	17.11	24.08	13.19

The last column of Table 2 presents the standard deviation of corporate tax rates for every year of our sample. To address the issue that the dispersion in tax rates may be driven by tax exemptions targeted at firms with a specific characteristic, we decompose the variance of corporate tax rates into within-group and between-group components. We group firms by observables provided in the ENIA, such as size, region, industry, and business entity type. Table 3 shows the average share of the within- and between-group components of the variance of corporate tax rates. For all group categorizations considered, the within-group component accounts for more than 97 percent of the total variance.

Table 3: Variance Decomposition of Corporate Taxes (percent)

Observable:	Within-Group Component	Between-Group Component
Size by Employment	98.79	1.21
Size by Sales	98.54	1.46
Size by Value Added	98.55	1.45
Region	99.15	0.85
Business Entity Type	97.14	2.86
Industry	98.77	1.23

Notes. This table portrays the share of the within-group and between-group components of the variance averaged for the period 1998-2007. Size categories for employment, sales, and value added are according to the standard categorization of 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.

## 2.3 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.

### 2.3.1 Monopolistic Competition Model

We consider a static monopolistic competition model with heterogeneous firms. We assume a small open economy with inelastic aggregate labor supply  $\bar{L}$ . 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, and it uses output  $Y_s$  of industries  $s \in \{1, \dots, S\}$  as inputs:

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

and  $P_s$  is the price of industry  $s$ .

Industry output is a CES aggregator of  $M_s$  differentiated products with elasticity parameter  $\sigma$ :

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

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

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

where  $K_{si}$  and  $L_{si}$  are the capital and labor inputs, respectively, and  $\alpha_s$  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:

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

where  $\pi_{si}^t$  is the economic profit of a firm that faces profit tax rate  $t_{si}$ , conditioned on non-negative accounting profit, and  $\pi_{si}^0$  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

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

where  $\lambda$  is the fraction of capital that is financed by debt and  $\Gamma_{si}$  is non-operational income net of non-operational costs.<sup>7</sup>

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

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

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

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

Maximization yields the following first-order conditions:

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

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

If a firm faces profit tax rate 0, economic profit  $\pi_{si}^0$  is

$$\pi_{si}^0 = \max_{\{K_{si}, L_{si}\}} \pi_{si}^A - \tilde{\tau}_{Y_{si}} P_{si} Y_{si} - (1 - \lambda) r K_{si} - \tilde{\tau}_{K_{si}} (r + \delta) K_{si}$$

$$\text{s.t. } \pi_{si}^A \leq 0 \quad (\mu_{si}^0),$$

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

Maximization yields the following first-order conditions:

---

<sup>7</sup>The parameter  $\lambda$  is exogenous and constant across firms in our quantitative analysis.  $\Gamma_{si}$  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.

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

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

Similar to Hsieh and Klenow (2009) and Foster et al. (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.

The industry-weighted average of firms' revenue productivity, marginal product of capital, and marginal product of labor are denoted as  $\overline{TFPR}_s$ ,  $\overline{MRPK}_s$ , and  $\overline{MRPL}_s$ , respectively. 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

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

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

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

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

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

We derive industry productivity as

$$TFP_s = \left[ \sum_{i=1}^{M_s} \left( A_{si} \frac{\overline{TFPR}_s}{\overline{TFPR}_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}}. \quad (14)$$

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

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

### 2.3.2 Measurement and Calibration

We use the data described in section 2.2.1 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. 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,  $P_s Y_s$ , 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.<sup>8</sup>

<sup>8</sup>Due to data availability, we only carry out this analysis for the period 2001-2007.

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 other papers in the literature. The elasticity of substitution between varieties is fixed at  $\sigma = 3$ , so that firms’ price is 50 percent higher than their marginal cost. In section 2.5.1, we evaluate the sensitivity of our results with respect to these assumptions. The capital share  $\alpha_s$  in industry  $s$  is equal to 1 minus the labor share in that corresponding industry for the United States.<sup>9</sup> These shares are obtained from the NBER Productivity Database.<sup>10</sup>

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

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

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

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<sup>11</sup>

<sup>9</sup>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.

<sup>10</sup>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.

<sup>11</sup>We cannot identify the capital and output wedges for firms that have accounting profits equal to 0, as we do not observe  $\mu_{si}^0$  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

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

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

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.

## 2.4 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.

### 2.4.1 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,  $\omega^K$  and  $\omega^L$ , are a function of firms' marginal products. Finally, aggregate capital demand changes for different tax rates and wedges through the marginal cost of capital. Note that by assumption, the aggregate demand on 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.

labor will not change since we have assumed a fixed aggregate labor supply.

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:

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

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

#### 2.4.2 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 4 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.

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

Year	Output Gap	TFP Gap	Intersectoral	Intersectoral	$\Delta$ Aggregate
			$K$	$L$	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

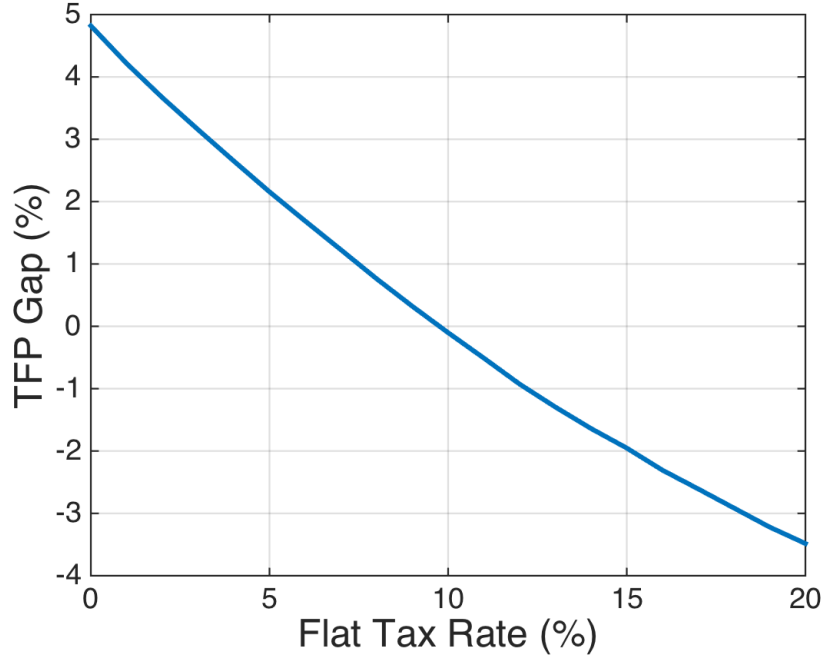
### 2.4.3 Allocative Efficiency and Corporate Tax Rates

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

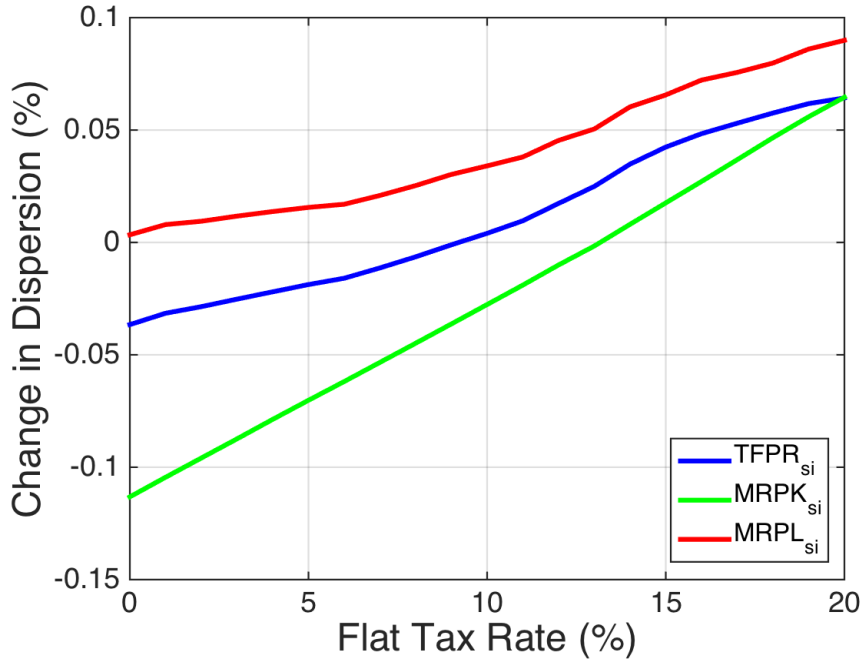
these counterfactual economies to the observed Chilean economy and measure changes in allocative efficiency with respect to the data.

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



The schedule in Figure 1 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 2: Change in Dispersion Measures Relative to  $\bar{t}$  (2003)



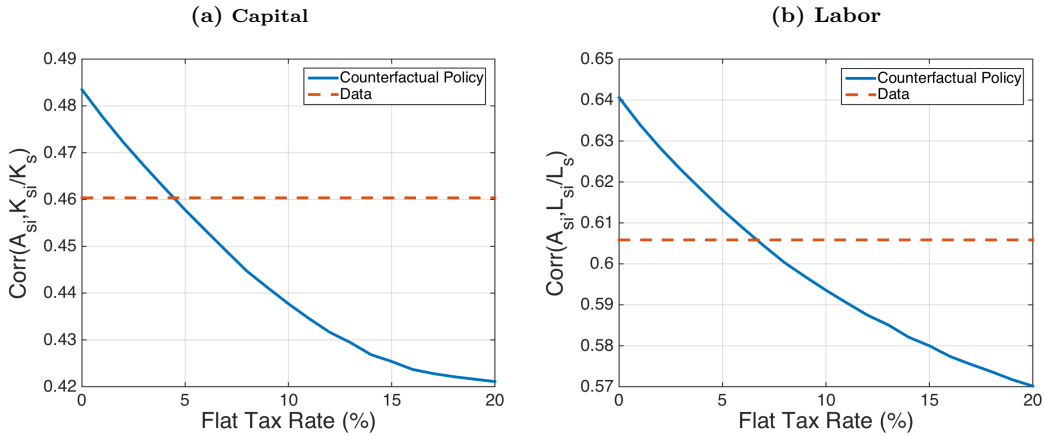
Notes: The change in dispersion for revenue productivity is measured as the log difference between the standard deviation of revenue productivity implied by the flat tax rate policy and the standard deviation of revenue productivity implied by the observed tax rates. The same statistic is calculated 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 2, 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.<sup>12</sup>

<sup>12</sup>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

To corroborate our results, we perform an alternative measure of allocative efficiency similar to Olley and Pakes (1996). Our results are summarized in Figure 3. 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.

Figure 3: Correlation between Firm Productivity and Activity Share (2003)



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.

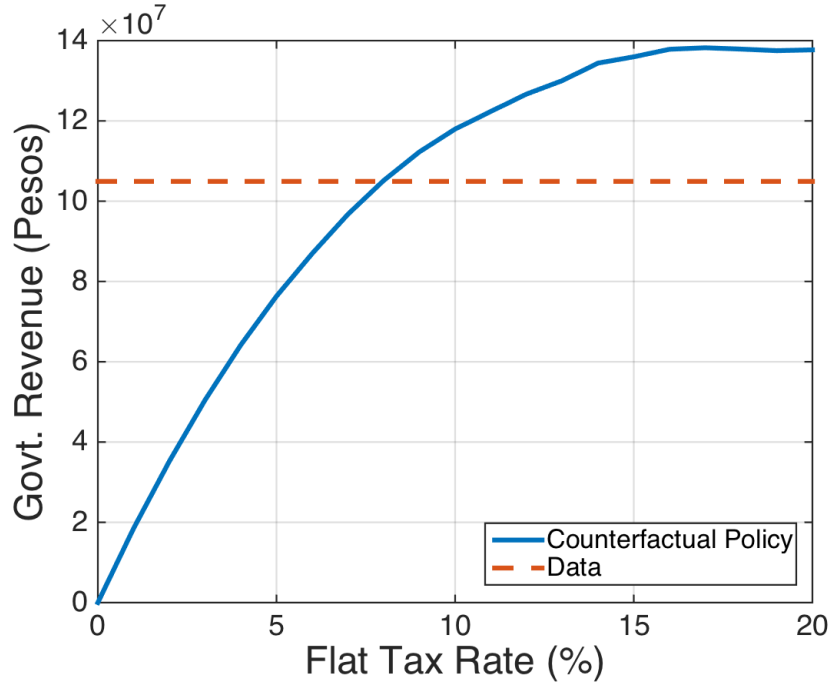
Next, we analyze the effect of these tax policies on government revenue. In Figure 4, the blue schedule labeled “Counterfactual Policy” portrays the Laffer curve for different flat tax rate policies. A clear trade-off stands out. Although very low flat tax rates yield higher levels of TFP, government 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

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drops as the tax levels increase.

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 4: 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.

## 2.5 Sensitivity Analysis

In this section, we analyze the sensitivity of the results in section 2.4 to our choice of parameter values and our measure of labor input.

### 2.5.1 Sensitivity to Parameter Values

Table 5 shows the TFP gap from eliminating corporate taxes for different interest rates  $r$ , depreciation rates  $\delta$ , and values of  $\sigma$ , 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  $\lambda$ .

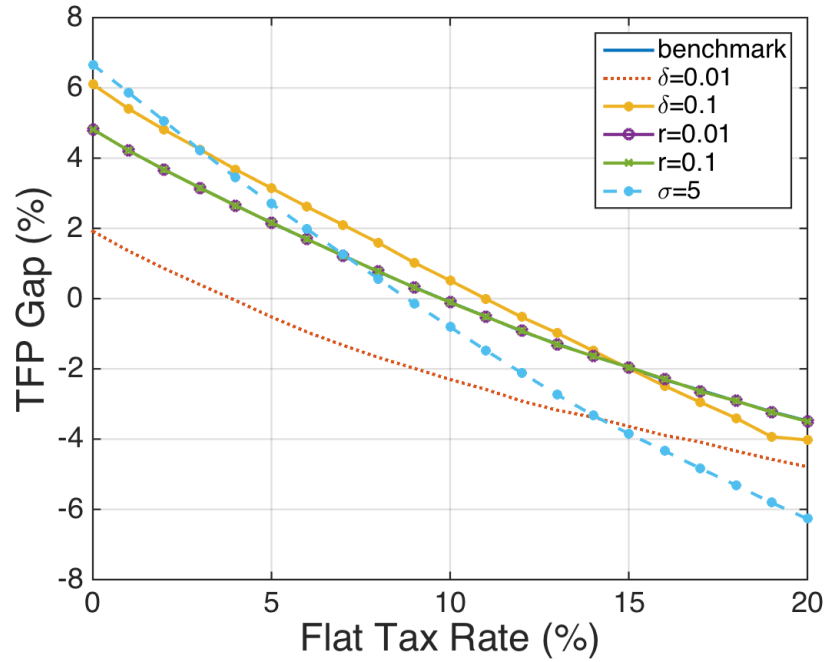
Table 5: TFP Gap for Different Parameter Values:  $t_{si} = 0$  (percent)

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  $\lambda$ . Moreover, as the depreciation rate increases, the TFP gains from eliminating corporate taxes are higher. Finally, we have chosen a conservative  $\sigma$  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 2.4.3, we carry out the same flat tax rate policy counterfactuals. Our results are robust when we consider different parameter values for  $r$ ,  $\delta$ , and  $\sigma$ . Figure 5 shows the same decreasing relationship between the TFP gap the level of the tax rate,  $\bar{t}$ , as the one found in Figure 1.

Figure 5: Relationship between TFP gap and  $\bar{t}$ : Parameter Sensitivity (2003)

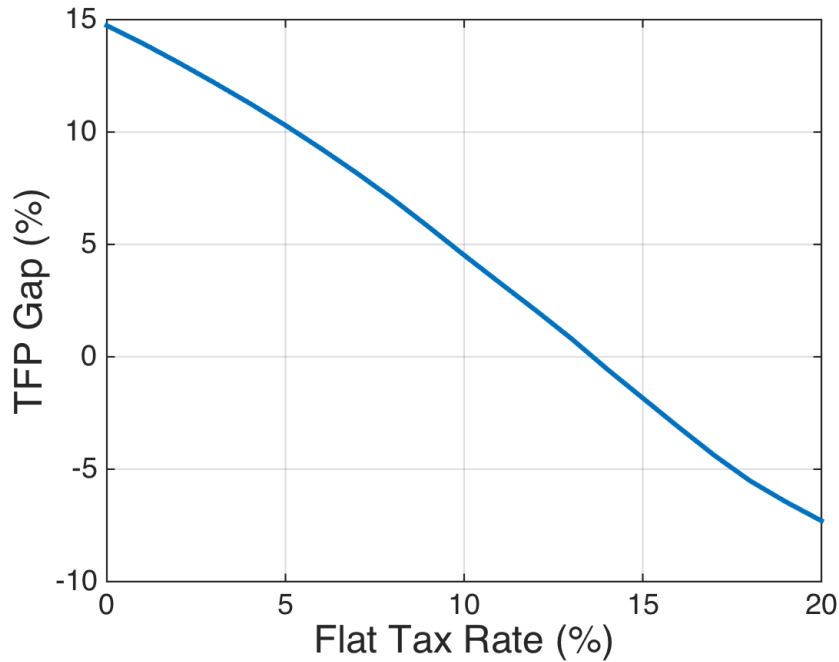


### 2.5.2 Hours Worked as Input for Labor

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.<sup>13</sup> 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.

<sup>13</sup>The data set analyzed has hours worked only for the years 2001-2007.

Figure 6: Relationship between TFP Gap and  $\bar{t}$ : Hours as Labor Input (2003)



Repeating our exercise with hours as labor input yields two main findings. First, in line with the results in section 2.4.3, the TFP gap falls when we increase the level of the corporate tax rate, as seen in Figure 6. 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 16 in the appendix.

## 2.6 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 address the issue of loss carryforward by firms, which could explain our results since we are considering a static model. Second, 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. 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.

### 2.6.1 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  $\lambda$  interacts with the effective tax rate  $t_{si}$  in the marginal revenue product of capital.

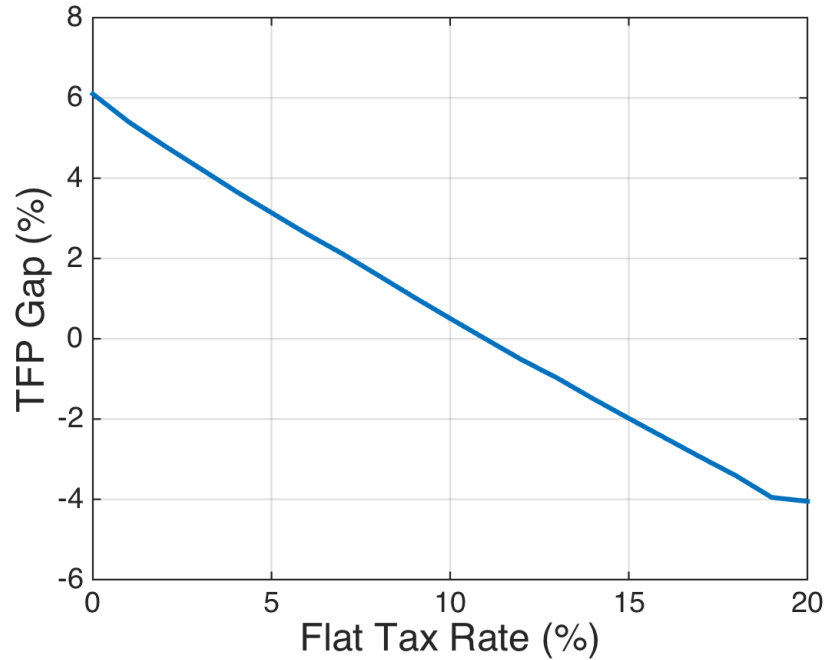
Note that if we observed profits before subtracting interest and taxes instead of using profits net of interest and taxes, differences in access to credit and other distortions that may affect the capital structure would also be loaded into the effective tax rate instead of the capital and output wedges. 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 6: Output gap decomposition:  $\lambda = 1$ ,  $t_{si} = 0$  (percent)

Year	Output Gap	TFP Gap	Intersectoral	Intersectoral	$\Delta$ Aggregate
			$K$	$L$	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

Table 6 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 4. 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 2.4.2.

Figure 7: Relationship between TFP Gap and  $\bar{t}$ :  $\lambda = 1$  (2003)



As in section 2.4.3, we carry out different counterfactual flat tax rate policies and evaluate their relationship to the TFP gap. In Figure 7 we can observe the same pattern as in Figure 1. 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 2.4.3, 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.

### 2.6.2 Accounting for Loss Carryforward

One of the exemptions that 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. 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 Tables 1 and 7.

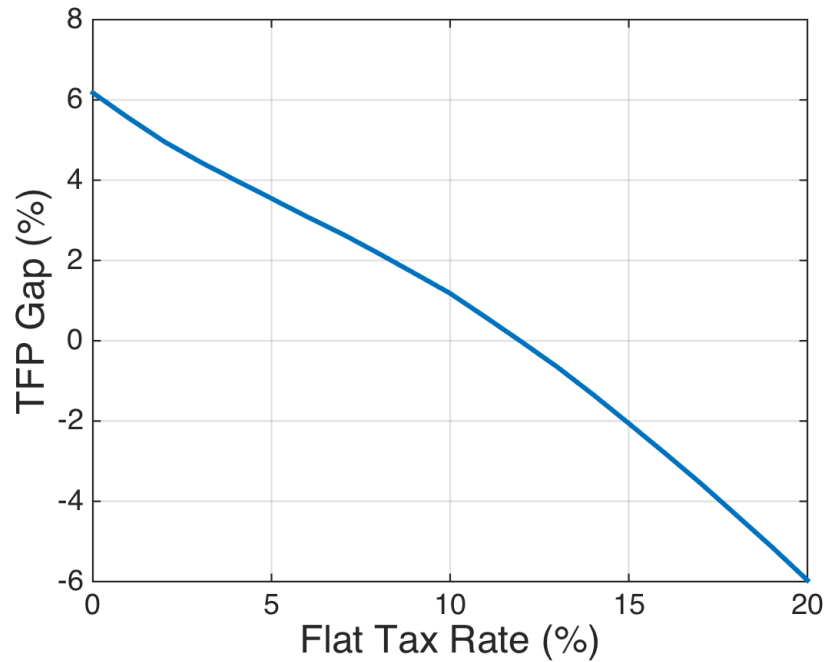
Table 7: Distribution of Effective Profit Tax Rates: Loss Carryforward (percent)

25th percentile	50th percentile	75th percentile	90th percentile	Standard Deviation
1.34	12.82	16.45	20.33	11.00

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 17 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 4. Hence, loss carryforward is not the main driver of the distortions generated by heterogeneous tax rates. Similar to section 2.4.2, 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 8. Hence, despite eliminating the dispersion in corporate tax rates coming from loss carryforward, as the flat tax rate increases, resources are allocated from more efficient firms to less efficient firms.

Figure 8: Relationship between TFP Gap and  $\bar{t}$ : Loss Carryforward (2003)



### 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 4. 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.<sup>14</sup> If the only source of tax rate dispersion was exemptions to less productive entrant

<sup>14</sup>We also perform the analysis for the years 1998 to 2002, and the results are very similar.

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 8, 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.

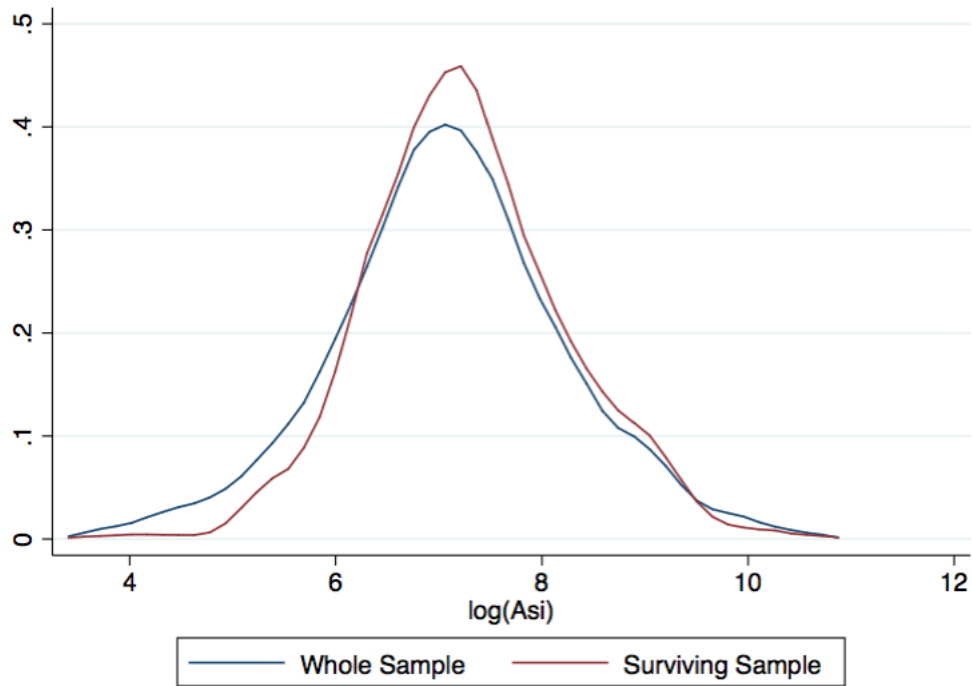
As shown in Table 18 in the appendix, there is significant dispersion in the effective corporate tax rates faced by the firms in the permanent sample for all years. Hence, tax exemptions given to young firms are not the main driver of this dispersion.

Table 8: Output Gap Decomposition: Permanent Sample,  $t_{si} = 0$  (percent)

Year	Output Gap	TFP Gap	Intersectoral	Intersectoral	$\Delta$ Aggregate
			$K$	$L$	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

By comparing Table 8 with Table 4, we can see that the results for intersectoral reallocation of resources and changes in input demands are similar. Also, 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 9, in which we compare the distribution of  $\log(A_{si})$  for the whole sample in comparison to the permanent sample for 2003.

Figure 9: 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.<sup>15</sup> 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 19 in the appendix.

## 2.7 Conclusion

The objective of this chapter 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.

<sup>15</sup>This finding is consistent with what Gopinath et al. (2017) find when analyzing Spanish firm-level data.

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.

## 3 Misallocation in Economies with Financial Frictions and Firing Costs

### 3.1 Introduction

Emerging economies are characterized as having underdeveloped financial markets. Moreover, many of these economies have employment protection laws that make it costly for firms to fire workers. These features hamper the allocation of resources across firms which in turn affects the total factor productivity (TFP) of an economy. Therefore, it is important to consider the full extent of their impact when evaluating financial or labor policy reforms. To accomplish this, it is key to understand the interaction between the level of financial development and labor protection legislation in a given economy.

This chapter quantifies the effect of a financial reform on TFP in an economy with firing costs. To do this, I develop a quantitative model of heterogeneous firms owned by entrepreneurs that face collateral constraints and have to pay firing costs. I then calibrate the economy using detailed census plant level data from the manufacturing sector in Chile, a country where firing costs are relatively high and a financial market that was not fully developed during 1995 to 2007, the period analyzed. Next, I carry out a counterfactual policy experiment where collateral constraints are relaxed to achieve the level of financial development of the United Kingdom.<sup>16</sup> I find that after the reform TFP increases by 2.5%. Importantly, if firing costs are excluded from the analysis, the increase in TFP after the reform is only 0.3%. Finally, I study the effect on productivity of the interaction between these two frictions when evaluating labor and financial reforms. I do this for a range of economies with plausible initial levels of financial development and firing costs.

This study brings together two strands of literature - that on financial friction as a source of low TFP in developing economies and that on the effects of firing costs on allocative efficiency and TFP - by studying the interaction of these sources of frictions on productivity. In general, the literature that studies financial frictions assume frictionless labor markets and do not incorporate the effect of labor policy into their analysis.<sup>17</sup> Similarly, the literature

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<sup>16</sup>Following the literature that studies the effect of financial frictions on TFP, I use external credit-to-output as a measure of financial development. The average credit to output ratio in the Chilean manufacturing sector during the period analyzed is 0.33. The same measure for the United Kingdom is 1.10.

<sup>17</sup>Examples of this literature are Buera et al. (2011), and Gopinath et al. (2017). Buera and Shin (2013) analyze the effects of financial frictions and incorporate a reduce form friction that affects labor choices of

studying the effects of firing costs on misallocation and productivity frequently abstracts from incorporating capital decisions into their analysis, or assumes capital markets with no frictions.<sup>18</sup> I incorporate both of these frictions into my analysis and find that studying them jointly is important to quantify the effect of both financial and labor market policies.

To study the effect of a financial reform in an economy with firing costs, I develop a general equilibrium small open economy model where entrepreneurs own firms that are heterogeneous in their productivity shock. Entrepreneurs have consumption and saving decisions, rent capital from international lenders and hire labor to produce. Capital is subject to a collateral constraint, hence entrepreneurs can rent it up to a multiple of their net worth. Moreover, they must pay firing costs proportional to wages when adjusting their level of labor downwards. As a result, firms are endogenously heterogeneous in their net worth and the level of past employment. To close the model, homogeneous workers supply labor inelastically and receive firing costs back as a transfer from the government. The calibrated model is able to reproduce cross sectional moments in the micro data as well as aggregate moments related to the two frictions analyzed.

In the model collateral constraints and firing costs interact as follows. Consider first an economy with only firing costs. In such economy, the allocation of labor is distorted. Firms with high past employment who receive bad productivity shocks do not fire workers since it is costly to do so. Firms with low past employment who receive good shocks do not hire as many workers, since they expect that their productivity might be low in the future and do not want to be stuck with a high level of past employment. In this economy, firms' net worth is irrelevant for their decisions since it is not used as collateral. Alternatively, consider an economy where only collateral constraints are present. Given a level of net worth, in this economy firms who receive good productivity shocks are more likely to be financially constrained than firms who receive bad shocks. Past employment is irrelevant for firms' decisions in this setting since there are no firing costs. Finally, consider an economy where both collateral constraints and firing costs are present. In this case, both the level of net worth and of past employment will have an impact on firms decisions. Given a level of net worth there can be four types of firms. Two types of firms were also present in the

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firms. However, they do not study the effects of specific labor policies in their analysis.

<sup>18</sup> Hopenhayn and Rogerson (1993), Veracierto (2001), Petrin and Sivadasan (2011), Da-Rocha et al. (2016)

previous economy with only financial frictions. These are firms with low past employment who receive bad shocks, and firms with high level of past employment who receive good shocks. The former will demand little labor and capital and as a result, are not likely to be financially constrained. The latter will demand a large amount of capital and labor, and therefore are likely to be financially constrained. However, there are two types of firms that only arise in this economy. Firms with high past employment who receive bad shocks will not fire workers, and since labor and capital are complements, will demand a large amount of capital. Hence, there will be some firms with bad shocks who will be financially constrained because they have hoarded too much labor and therefore demand more capital than in the economy with just financial frictions. Furthermore, there will be firms with low levels of past employment who receive good shocks that hire less workers than they would in the absence of firing costs. As a result, they will demand less capital and hence will be less likely to be financially constrained. This interaction is the driver of the quantitative results of the policy evaluations.

To carry out the quantitative analysis I calibrate the model using the data set described in Chapter 1. The richness of the data makes it possible to estimate firms' production functions using Wooldridge (2009) method, a refinement to Levinsohn and Petrin (2003) and Olley and Pakes (1996). Thus, productivity and technology parameters are estimated directly from the micro data. In the period I analyze is 1995-2007. During this period, there were no labor reforms and the financial market remained relatively stable.<sup>19</sup> This is important since in the calibration I will assume that the economy is in a steady state.

Using the model described above calibrated to the Chilean economy, I study the effect of a financial reform that increases Chile's external credit-to-output ratio to the level of the United Kingdom. I find that, in the long run, the reform generates an increase in TFP of 2.5%. This is driven by a sharp improvement in the allocation of capital, which is achieved through a direct and an indirect channel. Directly, through the relaxation of the collateral constraint, which implies that firms require less net worth to become financially unconstrained. Indirectly, since the reform induces an increase in wages which leads to an increase in the effective cost of firing and hence firms with low past employment who receive

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<sup>19</sup>Between 1991 and 1998 there was a 30% unremunerated reserve requirement imposed in Chile for all new credit. Empirical evidence suggests that it had small effects on the real exchange rate. See Andreasen et al. (2018)

high productivity shocks hire less labor and demand less capital.<sup>20</sup> The increase in wages also worsens the allocation of labor, as measured by an increase in the dispersion of the marginal product of this input. However, this effect is not strong enough to offset the gains from a better allocation of capital.

To study the importance of incorporating firing costs into the analysis, I recalibrate the model to Chile ignoring firing costs and perform the same policy counterfactual. In this economy, TFP increases by only 0.3% after the reform. The difference stems from the type of firms that are constrained and the fact that the indirect effect is not present in this economy.

To further explore how these two frictions interact, I analyze different economies within a plausible range of levels of both collateral constraints and firing costs. I perform two different policy counterfactuals. First, I explore the effects of relaxing the collateral constraint for economies with different levels of firing costs. Second, I study how economies with different levels of financial development are affected by an increase in firing costs.

Regarding the first counterfactual, I find that there is a non-monotonic relationship between the increase on TFP following a financial reform and the level of the firing cost in the economy. There are two reasons for this. First, in economies with low firing costs, wages are more elastic to a relaxation of the collateral constraints and as a result, the effective cost of firing a worker increases more than in economies with higher firing costs. Thus, the distortion of the allocation of labor offsets some of the gains from the improvement in the allocation of capital. Furthermore, if the firing cost is too high, there is little reallocation of labor and hence little reallocation of capital. Second, the type of firms that are constrained prior to the reform is different for different levels of firing costs. In economies with low firing costs, firms do not hoard labor since it is relatively cheap to adjust it. In economies where the firing cost is too high, firms are discouraged from growing and thus will not have large levels of past employment. In these two types of economies, the firms that are financially constrained will be mostly firms who receive high productivity shocks. As a result, the impact on TFP of relaxing the collateral constraint will be lower relative to economies with moderate levels of firing costs. In such economies, firms who hoard labor, and hence demand more capital, will be financially constrained even after receiving bad productivity shocks.

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<sup>20</sup>Since firing costs are proportional to wages, an increase in the wage increases the effective cost of firing.

When studying how labor policy affects economies with different levels of financial development, I find that economies with more developed financial markets suffer a smaller drop on TFP after an increase in firing costs. There are two effects driving this result. First, in economies where the level of financial development is higher, firms use less internal resources to rent capital, relative to economies with tighter collateral constraints. As a result, firms can use some of their profits to pay for the firing cost and have a better allocation of labor. Second, given an increase in firing costs, the allocation of capital is worsened, driven by firms who hoard too much labor and thus demand too much capital. This negative effect is ameliorated in economies where financial constraints are loose.

Increasing firing costs has direct implications for the capital-labor ratio of the economy. Interestingly, the model replicates the findings of the empirical literature that studies the effect of firing costs on firm investment. This literature finds that the relationship between the capital-labor ratio and firing costs is hump-shaped. In my analysis, there is a slight increase in capital-labor ratio following an increase in firing costs in economies with a low level of firing costs. This is consistent with the findings of Autor et al. (2007) who study the implications on firm investment of the adoption of wrongfully discharged protection by state courts in the United States. Moreover, in economies with relatively high levels of financial development and firing costs, an increase in firing costs generates a decrease in the capital-labor ratio. This is in line with the findings of Calcagnini et al. (2009) and Cingano et al. (2014) who find a negative relation between firing costs and capital-labor ratio in European economies.

The remainder of the chapter is organized as follows. Section two describes the chapter's relation and contribution to the literature. In section three I develop the model that will be used through out the analysis. Section four describes the data, calibration and the fit of the model. I present the results of the financial reform in section five. Section six analyzes the implications of financial and labor policy reforms in economies with a plausible range of both firing costs and collateral constraints. I conclude in section seven.

## **3.2 Literature Review**

This chapter contributes mainly to two strands of literature by bringing them together, that one that studies financial frictions as a source of low TFP in developing countries, and that

studying the effect of firing costs on the allocation of resources and productivity.

Regarding the first one, Midrigan and Xu (2014) find that financial frictions have little impact on productivity through capital misallocation. They study an environment with frictionless labor markets and find that most of the effect of the financial frictions on TFP comes from distorting the decisions of firms to upgrade technology. Similarly, Buera et al. (2011) also find that the most important channel is the extensive one, in an environment with no labor frictions. I focus on the impact of financial frictions on the allocation of resources and incorporate a relevant labor market policy that affects the way these resources are allocated.

With respect to the second strand of literature, an early example is Hopenhayn and Rogerson (1993). This study abstracts from capital allocation and studies the effect of firing costs on firms decisions to operate and how labor is allocated across them. They find that firing costs reduce productivity, mainly from the extensive margin. Veracierto (2001) builds on the previous study and incorporates capital choice into the analysis. He finds that incorporating capital is not important for understanding the long run and welfare effects of firing taxes, but it does impact the short run implications of eliminating firing costs. Importantly, he assumes that the capital market is frictionless. I add collateral constraints into the analysis and find that the level of financial development is important to understand the long term consequences of imposing firing costs. Petrin and Sivadasan (2011) study the impact of firing costs in Chile after a labor reform in 1991 that increased the ceiling of severance payments from five monthly wages to eleven. They find that the allocation of labor worsened after the reform. Da-Rocha et al. (2016) study an environment where firing costs not only distort the allocation of resources but also affect the underlying distribution of firms' productivity. They find that this channel is important in explaining the impact of firing costs on aggregate productivity. There is no capital decision in the model. Overall the literature on financial frictions and development has ignored labor market policies and the literature on firing costs abstracts from distorted capital markets. To the best of my knowledge this is the first study to analyze these two frictions together and quantify the effect of their interaction on the allocation of resources and TFP.

This chapter also contributes to the empirical literature studying the impact of the interaction between the level of financial development and firing costs in firm investment

and productivity. Calcagnini et al. (2009) use firm level data from ten European countries and perform an estimation of a dynamic panel model. They find that financial frictions are positively correlated with firms' cash holdings and these are larger in countries with more strict employment protection legislation. Another study by Calcagnini et al. (2014) finds that investment is affected by the presence of both frictions and that the effect of labor market regulation is weaker in countries with more developed financial markets. I find qualitatively similar results. Cingano et al. (2014) estimate the impact of firing costs on capital deepening and productivity. They analyze a specific reform in Italy where firms with less than fifteen employees ceased to be exempt from paying firing costs. They find that firing costs induced an increase in the capital to labor ratio and a decline in TFP. Moreover, the firms most affected by the reform were firms with low levels of liquidity, their proxy for financial frictions. I contribute to this literature by developing and calibrating a structural model that allows to study counterfactual policies in the presence of both financial frictions and firing costs.

Finally, this study is also related to a large literature that studies the impact of financial frictions on labor outcomes. Buera et al. (2015) study how a credit crunch following the 2007-2008 financial crisis in the U.S. affected output, unemployment and net employment growth. Arellano et al. (2016) analyze how a tightening in financial conditions affected output and labor during the recession of 2007-2009. I contribute to this literature by analyzing the interaction of financial frictions with a specific labor market distortion, namely firing costs.

### **3.3 Model**

This section provides a description of the theoretical model used for the analysis of a financial reform. The two key ingredients are collateral constraints faced by firms and labor adjustment costs that firms have to pay.

#### **3.3.1 Setting**

I consider a small open economy populated by two types of agents: entrepreneurs and workers. Time is discrete and infinite, and there is only one type of good in the economy. Capital is rented by entrepreneurs from international financial intermediaries.

### 3.3.2 Agents

**Entrepreneurs** There is a measure one of infinitely lived entrepreneurs. Every period, each entrepreneur receives an idiosyncratic productivity shock  $z_t$  which evolves according to an AR(1) process. They are heterogeneous in their productivity shock  $z_t$ , level of net worth  $a_t$ , and past employment  $\ell_{t-1}$ . Each entrepreneur can only own one firm. They have preferences over consumption given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \quad u(c) = \frac{c^{1-\sigma}}{1-\sigma}. \quad (21)$$

The firm owned by the entrepreneur uses capital  $k_t$  and current employment  $\ell_t$  to produce

$$y_t = z_t (k_t^\alpha \ell_t^{1-\alpha})^\nu,$$

where  $z_t$  is the productivity shock,  $\alpha \in (0, 1)$  is the output elasticity of capital, and  $\nu$  is the span of control parameter that controls the decreasing returns to scale.

**Workers** There is a unit measure of homogeneous hand-to-mouth workers. Workers preferences are

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(C_t^\omega),$$

where  $C_t^\omega$  is the aggregate consumption of all workers and  $u(c)$  is the same as defined above.

**International lenders** International lenders rent capital and receive deposits from entrepreneurs. The return on deposits is  $r_t$ . Lenders are competitive and the zero-profit condition implies that the rental cost of capital  $R_t = r_t + \delta$ . Capital is rented intraperiod, and the amount an entrepreneur can rent is subject to a collateral constraint. In particular, entrepreneurs can rent up to a multiple  $\lambda$  of their net worth,  $k_t \leq \lambda a_t$ . This captures the level of financial development in the economy.<sup>21</sup> All entrepreneurs are subject to the same collateral constraint.

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<sup>21</sup>This type of constraint has been extensively used in the financial development literature. See for example Buera and Shin (2013) and Moll (2014).

### 3.3.3 Problem of the Entrepreneur

Entrepreneurs make consumption/savings decisions, hire labor in a competitive market at a wage  $w_t$  and rent capital from international lenders. There is a firing cost that is proportional to wages,  $w_t g(\ell_{t-1}, \ell_t) = \tau \max\{0, \ell_{t-1} - \ell_t\}$ .<sup>22</sup> The entrepreneur's budget constraint is

$$c_t + a_{t+1} = y_{it} - w_t \ell_t - R_t k_t - w g(\ell_{t-1}, \ell_t) + (1 + r) a_t. \quad (22)$$

The problem of the entrepreneur can be written recursively. Let the individual state of a particular entrepreneur be her net worth  $a$ , past employment  $\underline{\ell}$ , and productivity shock  $z$ . The recursive problem is to maximize the value function:

$$V(a, \underline{\ell}, z) = \max_{\{c, k, \ell, a'\}} u(c) + \beta \mathbb{E}_{z'|z} V(a', \ell, z') \quad (23)$$

subject to

$$\begin{aligned} c + a' &= z (k^\alpha \ell^{1-\alpha})^\nu - w \ell - (r + \delta) k - w g(\underline{\ell}, \ell) + (1 + r) a \\ k &\leq \lambda a. \end{aligned}$$

### 3.3.4 Problem of the Worker

Workers supply labor inelastically and receive transfers from the government. These transfers are the sum of the firing costs paid by firms. Hence, given a wage  $w$  and transfers  $T$ , total consumption of workers is given by

$$C^\omega = w + T$$

### 3.3.5 Equilibrium

Given  $r$ , a stationary equilibrium is a wage  $w$ , an endogenous distribution of entrepreneur types  $\mu$ , entrepreneurs' choices  $c(a, \underline{\ell}, z, \mu)$ ,  $k(a, \underline{\ell}, z, \mu)$ ,  $\ell'(a, \underline{\ell}, z, \mu)$ ,  $a'(a, \underline{\ell}, z, \mu)$ , and workers' consumption  $C^\omega$ , such that:

1. Given  $w$  and  $r$ , the policy functions for the firm,  $c(a, \underline{\ell}, z, \mu)$ ,  $a'(a, \underline{\ell}, z, \mu)$ ,  $\ell(a, \underline{\ell}, z, \mu)$ , and  $k(a, \underline{\ell}, z, \mu)$ , solve the entrepreneur's problem (23).

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<sup>22</sup>See Section 3.4 for details on the functional form choice.

2. The labor market clears:

$$1 = \int \ell(a, \underline{\ell}, z, \mu) d\mu(a, \underline{\ell}, z, \mu)$$

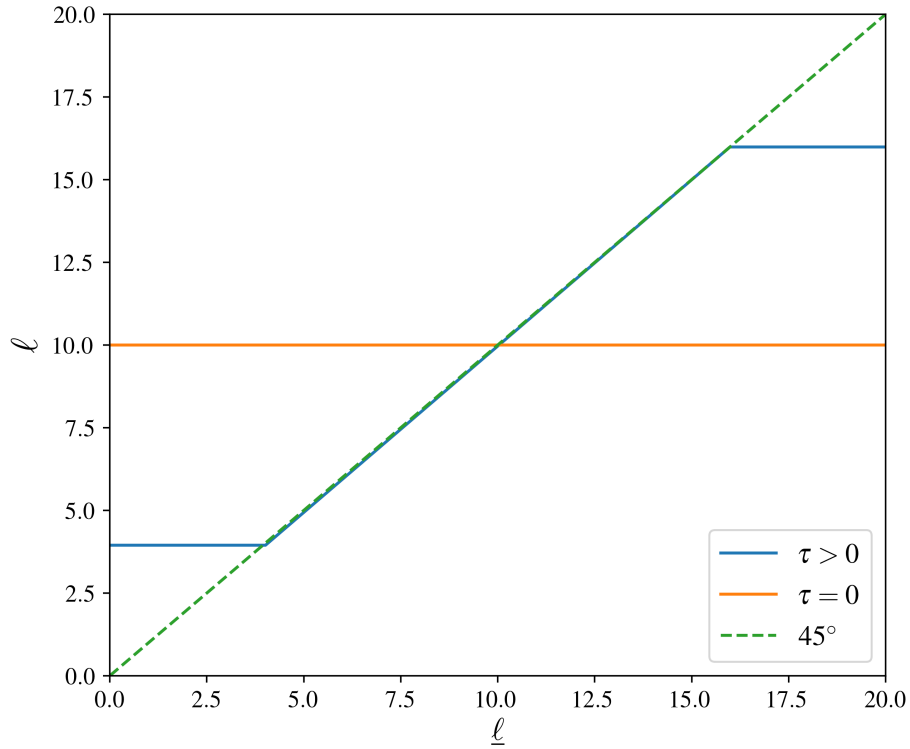
3. The good market clears:

$$\begin{aligned} C^\omega + \int c(a, \underline{\ell}, z, \mu) d\mu(a, \underline{\ell}, z, \mu) &= \int z \left( k(a, \underline{\ell}, z, \mu)^\alpha \ell(a, \underline{\ell}, z, \mu)^{1-\alpha} \right)^\nu d\mu(a, \underline{\ell}, z, \mu) \\ &\quad - \delta \int k(a, \underline{\ell}, z, \mu) d\mu(a, \underline{\ell}, z, \mu) \\ &\quad + r \int [k(a, \underline{\ell}, z, \mu) - a] d\mu(a, \underline{\ell}, z, \mu) \end{aligned}$$

### 3.3.6 Interaction Between Firing Costs and the Collateral Constraint

To understand why the firing cost and the collateral constraint interact, it is convenient to look at the policy function of labor with respect to past employment, given net worth  $a$  and current productivity shock  $z$ . This is shown in Figure 10. The solid line is the policy function when  $\tau > 0$ , the dotted line represents the policy function when  $\tau = 0$ , and the dashed line is the 45 degree line. The key aspect of the policy function when  $\tau > 0$  is that there is an inaction zone in which the firm does not adjust labor. Moreover, the firm only hires if the level of past employment is very low (in this case, below 5) and only fires if past employment is too high (in this example, above 15). Note that if firing costs are 0, the labor choice does not depend on past employment. Hence, firms with high past employment who receive bad shocks may end up with more labor relative to the case when  $\tau = 0$ . Alternatively, firms who receive good shocks and have low past employment may hire less labor than they would in an economy with no firing costs. Since capital and labor are complements, these distortions in labor will translate into firms demanding too much or too little capital relative to the case when  $\tau = 0$ . On one hand, there will be firms with high past employment who receive bad shocks that will demand a large amount of capital, and will be more likely to be financially constrained relative to an economy with no firing costs. On the other hand, there will be firms with a low level of past employment who receive good shocks and demand less capital than in the economy with  $\tau = 0$ . These firms will be less likely to be financially constrained.

Figure 10: Labor Policy Function for a given  $a$  and  $z$



### 3.4 Parametrization

In this section, I describe how I parameterize the model described above to match key features of the Chilean economy and its manufacturing sector. I choose parameters on preferences, technology and the stochastic process of firm specific productivity. One period is set to be a year.

I need to determine nine parameter values: two technological parameters,  $\alpha$  and  $\nu$ ; two parameters governing the productivity process that firms face,  $\rho$  and  $\sigma$ ; the coefficient of risk aversion,  $\gamma$ ; and the discount factor  $\beta$ ; the firing cost  $\tau$  and the collateral constraint parameter  $\lambda$ .

#### 3.4.1 Data

The main data set used is the ENIA (Encuesta Nacional Industrial Anual), the data set described in Chapter 1. I use data for the period 1995-2007, as there were no reforms in the

labor market during this time frame, and financial conditions were stable. This is important since I will assume the economy is in a steady state when calibrating the model. Moreover, after 2007 the data set has no way of linking firms across time. For the estimation of the productivity process and the span of control parameter I use the permanent sample of firms.

To construct the sample used in this analysis, I drop observations with negative values for book value of capital, gross revenue, intermediate materials, wage bill, services, and electricity. To control for outliers, I trim the top and bottom 1% of these variables. The data set comes with four-digit industry deflators for gross revenue and intermediate inputs that I use to deflate the relevant variables.

### 3.4.2 Firing Costs

To study the role of firing costs in this economy, I set  $g(\underline{\ell}, \ell) = \tau \max\{0, \underline{\ell} - \ell\}$ . This functional form has been used extensively in the literature.<sup>23</sup> Moreover, this specification is a reduced form of capturing the way firing costs work in Chile. In Chile, a worker who is fired for economic reasons has to be given a one month notice or be paid one monthly wage to be dismissed immediately. Moreover, she has to be paid one monthly wage per year worked at the firm, up to 11 months. There are also judicial fees and other costs. To calculate the flow cost of firing a worker in Chile, I use the estimate from Heckman and Pagés (2003). In this study, the authors measure the direct cost as a fraction of monthly wages, of job security provision. These costs include the costs of dismissing a worker for economic reasons. This includes administrative procedures, advanced notification, severance payments, and the legal costs of a trial if workers contest dismissals. They then calculate the present discounted cost of firing a worker. To do this, they assume a discount rate and dismissal rate of 8 and 12 percent respectively. The discount rate is motivated by the historical return of an internationally diversified portfolio. The turnover rate is that of the United States. Finally, they assume that the maximum tenure that a worker can attain in a firm is twenty years. According to their assumptions, the expected discounted value of firing a worker in Chile is 3.4 monthly wages. Using their assumptions, I then back out the flow cost of firing a worker in Chile. I find this to be 5.6 monthly wages.<sup>24</sup> Since a period

<sup>23</sup>See Hopenhayn and Rogerson (1993), Veracierto (2001), Da-Rocha et al. (2016)

<sup>24</sup>I do robustness on the maximum amount of tenure a worker can get, and set it to be a very large number. The flow cost is then 5.74 monthly wages .

in my model is a year, I then set  $\tau = 0.47$  to match the flow cost of dismissal.

Most of this cost is comprised by severance payments. Lazear (1990) points out that, in absence of any other friction, a contract can be written specifying a side payment from the worker to the firm that fully offsets the firing cost. Petrin and Sivadasan (2011) study the effect of a change in the dismissal cost in Chile in 1990, and find no clear evidence that the changes on job security were offset through lower wage rates. Moreover, in a setting where firms are subject to financial constraints, the timing of dismissal matters since this would reduce the resources available for the firm to increase their net worth.

### 3.4.3 Productivity Process and Span of Control Parameter

To estimate the firm productivity and span of control parameters I use Wooldridge (2009) extension of Levinsohn and Petrin (2003) methodology to estimate firms' production function. Using the panel data described in Section 3.4.1, I estimate the following gross output production function:

$$y_{ist} = \beta_k^s k_{ist} + \beta_\ell^s \ell_{ist} + \beta_v^s v_{ist} + \beta_e^s e_{ist} + \beta_m^s m_{ist} + \varepsilon_{ist} \quad (24)$$

where  $y_{ist}$  is the log of gross output,  $k_{ist}$  is the log of book value of capital,  $\ell_{ist}$  is the log of wage bill,  $v_{ist}$  is the value of services,  $e_{ist}$  is the log of the quantity of electricity used, and  $m_{ist}$  is the log of materials used by firm  $i$  in industry  $s$  at time  $t$ . Gross output is deflated using a four-digit industry deflator for gross output. Services, materials and wage bill are deflated by a four-digit industry intermediate input deflator. Capital is deflated using an investment deflator.<sup>25</sup> The estimation is done separately for each 2-digit industry.

The error is assumed to be

$$\varepsilon_{ist} = \Omega_{ist} + \eta_{ist}$$

where  $\Omega_{ist}$  is the transmitted component of the firm specific productivity shock, and  $\eta_{ist}$  is the i.i.d. firm specific productivity shock. The idea of the method used is to express the transmitted component as a function of the state variables and a proxy variable. Following Levinsohn and Petrin (2003), I use materials as a proxy variable.<sup>26</sup> Moreover, since there

<sup>25</sup>I follow Gopinath et al. (2017), Hsieh and Klenow (2009) and others in measuring capital by its book value.

<sup>26</sup>Olley and Pakes (1996) use investment as a proxy variable. Due to lumpiness in investment, there are missing variables for a number of observations. I use materials since all the firms in my data have positive

are adjustment costs to labor in the model analyzed, I include labor as a state variable, in addition to capital. Hence, given some function  $h(\cdot, \cdot)$ , I assume the transmitted component to be:

$$\Omega_{ist} = h(\mathbf{x}_{ist}, m_{ist})$$

where  $\mathbf{x}_{ist} = (\ell_{ist}, k_{ist})$  is the vector of state variables.

Three more assumptions are needed to identify the parameters of the production function:

1. The state variables are uncorrelated with the innovation:

$$b_{ist} \equiv \Omega_{ist} - E(\Omega_{ist} | \Omega_{ist-1})$$

2. Lagged states and proxy variables are uncorrelated with the innovation:

$$\begin{aligned} E(\mathbf{x}_{ist}, \mathbf{x}_{ist-1}, \phi_{ist-1}, m_{ist-1}, \dots, \mathbf{x}_{is1}, \phi_{is1}, m_{is1}) &= E(\Omega_{ist} | \Omega_{ist-1}) \\ &\equiv F[h(\mathbf{x}_{ist-1}, m_{ist-1})] \end{aligned}$$

where  $\phi_{ist} = (e_{ist-1}, v_{ist-1})$  is the vector of variable inputs.

3. An orthogonality condition

$$E(b_{ist} + \varepsilon_{ist} | \mathbf{x}_{ist}, \mathbf{x}_{ist-1}, \phi_{ist-1}, m_{ist-1}, \dots, \mathbf{x}_{is1}, \phi_{is1}, m_{is1}) = 0.$$

Finally, the function used in the estimation is

$$y_{ist} = \beta_k^s k_{ist} + \beta_\ell^s \ell_{ist} + \beta_v^s v_{ist} + \beta_e^s e_{ist} + \beta_m^s m_{ist} + F[h(\mathbf{x}_{ist-1}, m_{ist-1})] + b_{ist} + \varepsilon_{ist}$$

I approximate  $F[h(\mathbf{x}_{ist-1}, m_{ist-1})]$  using general second order polynomial, and use first and second lags of electricity and services, and second lags of wage bill as instruments.

I use the estimated elasticities, and the residuals of the estimation to calculate both the span of control parameter used and to estimate the productivity process.

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non missing observations for this variable.

**Span of control parameter** The returns to scale are in the range of 0.75 and 1.03 depending on the industry.<sup>27</sup> These values are in line with other estimates from micro-data.<sup>28</sup> The median of these estimates (0.85) is used as the span of control parameter  $\nu$ .

**Productivity process** The idiosyncratic productivity process is an AR(1) in logs:

$$z_t = -\frac{\sigma^2}{2(1+\rho)} + \rho z_{t-1} + \sigma u_t^z, \quad \text{with } u_t^z \sim N(0, 1) \quad (25)$$

where  $\rho$  is the persistence of the productivity process and  $\sigma$  is the standard deviation of the idiosyncratic productivity shock  $u_t^z$ . The constant term normalizes the mean of the idiosyncratic productivity to 1.

To back out these parameters, I used the fitted values of the production function estimation to back out  $\hat{\epsilon}_{ist}$ .<sup>29</sup>

I then run the following regression:

$$\hat{\epsilon}_{ist} = \eta_i + \eta_{st} + \hat{\rho}\hat{\epsilon}_{ist-1} + \epsilon_{ist},$$

where  $\eta_i$  and  $\eta_{st}$  are a firm fixed effect and an industry-year fixed effect respectively. I then set  $\sigma = 0.48$  to match the average of the cross sectional variance of  $\epsilon_{ist}$ .<sup>30</sup> Including fixed effects generates a downward bias in the estimate of  $\hat{\rho}$  due to the short time series. To overcome this caveat, I set  $\rho = 0.42$  so that in the model generated data of 13 sample periods, the estimate persistence parameter equals 0.272, which is the value of  $\hat{\rho}$  in the data. Note that in the data, the standard deviation of  $\log(\hat{\epsilon}_{ist})$  is equal to 0.67. The model implied standard deviation for  $\log(z)$  is 0.61.<sup>31</sup>

<sup>27</sup>Table 19 in the Appendix summarizes other moments of the span of control parameters found in the data.

<sup>28</sup>Petrin and Sivadasan (2011) use an earlier version of the ENIA and find 3-digit industry estimates to be between 0.82 and 1.06. Gopinath et al. (2017) do this for a set of European countries and find similar values

<sup>29</sup>To control for outliers, I drop the top and bottom 1% of fitted values  $\hat{\epsilon}_{ist}$  per year

<sup>30</sup>To calculate this measure, I drop the top and bottom 1% of the error terms per year.

<sup>31</sup>To maximize the length of the sample used, I estimate of the productivity process using firms that were active for all periods in the sample.

Table 9: Parameters

Parameter	Description	Value	Source
Internally Calibrated:			
$\lambda$	Collateral Constrain	1.35	Superintendencia de Bancos de Chile
Externally Calibrated			
$\nu$	Span of Control	0.85	ENIA 1995-2007
$\rho$	Auto-correlation productivity process	0.42	ENIA 1995-2007
$\sigma$	Variance of innovation AR(1)	0.48	ENIA 1995-2007
Other Parameters			
$r$	Real interest rate	6.45%	Banco Central Chile
$\gamma$	CRRA parameter	2.0	
$\delta$	Depreciation	0.06	
$\beta$	Discount factor	0.92	
$\alpha$	Capital elasticity	0.36	ENIA 1995-2007

Note: The collateral constraint parameter is set to match the external credit-to-output ratio of Chile in the manufacturing sector equal to 0.33. The externally calibrated parameters are obtained from estimating firms' production function using Wooldridge (2009) method. The interest rate is the average across years of the difference between the nominal interest rate on commercial loans and next year's expected inflation. The capital elasticity is set to match the labor share calculated from the ENIA for the period analyzed. Parameters without source are conventional parameters from the financial frictions literature.

### 3.4.4 Other Parameters

**Collateral Constraint** I calibrate  $\lambda$  by requiring that the model matches the external finance-to-value added ratio for the manufacturing sector of the Chilean economy which is equal to 0.33. This value is taken from the *Superintendencia de Bancos e Instituciones Financieras de Chile*, who measures the total credit balances for the manufacturing industries included in the data base.

**Real Interest Rate** I measure the real exchange rate,  $r$ , as the average across years of the difference between the nominal interest rate on commercial loans and next year's expected inflation. This information is taken from the Banco Central de Chile.

**Conventional parameters** The reminder of the parameters are chosen from conventional values in the literature. I set  $\gamma = 2$ ,  $\alpha = 0.33$ , the 1-year depreciation rate is set at  $\delta = 0.06$ , and the discount factor is set to be  $\beta = 0.92$ .

### 3.4.5 Model Fit

This section summarizes the fit of the model. To do this I compare the cross-sectional implications of the model against the micro data. Table 10 summarizes these findings.

The model does a good job capturing the dispersion of labor in the economy. Since I do not incorporate adjustment costs of capital or time-to-build into the model, capital is more volatile in the model than in the data, since these features are likely to hamper capital dispersion. This also explains why output is more volatile in the data than in the model.

As an external check on the calibration of the firing cost, I calculate the mean across years of the share of firms that pay severance payments (and hence firing costs) in the data and compare it to the model.<sup>32</sup> In the data, this share is 0.22, while in the model is 0.30.

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<sup>32</sup>I do this for the years 1995 to 2001, since those are the years in which I have data on severance payments.

Table 10: Cross-sectional Moments, Model and Data

Moment	Data	Model
S.D. ( $\log z$ )	0.67	0.61
S.D. ( $\log \ell$ )	1.05	2.41
S.D. ( $\log k$ )	1.60	2.43
S.D. ( $\log y$ )	1.08	2.48
Top 30% Share Agg. Labor	0.70	0.90
Top 30% Share Agg. Capital	0.80	0.92

Note: standard deviations of variables in the data are the average standard deviation across the years 1996 to 2007.

### 3.5 Financial Reform in Chile

In this section I evaluate the effects of a financial reform in Chile. To do this, I use the baseline calibration and explore the effects of increasing the external credit-to-output ratio of Chile from 0.33 to 1.10, a level similar to that of the United Kingdom during the period analyzed.<sup>33</sup>

To study the effects of the reform on productivity, I will first define a measure of total factor productivity and marginal products of capital and labor.

Let total factor productivity be defined as

$$TFP := \frac{Y}{K^\alpha L^{1-\alpha}} \tag{26}$$

which is consistent with other studies in the literature.<sup>34</sup>

<sup>33</sup>The UK is a good example since it had a per period cost of firing a worker of 2.5 monthly wages during the period analyzed and its credit-to-output ratio was high. See Heckman and Pagés (2003)

<sup>34</sup>See Restuccia and Rogerson (2008), and Buera and Shin (2013) for an economy where firms have decreasing returns to scale and TFP is defined as in 26. As a robustness check, I redefine TFP to be  $TFP := \frac{Y}{(K^\alpha L^{1-\alpha})^\nu}$  as in Midrigan and Xu (2014) and get similar results.

The marginal product of capital and labor for a given firm  $i$  with idiosyncratic state  $(a, \underline{\ell}, z)$  are

$$MRPL := \nu(1 - \alpha) \frac{y_i}{\ell_i} = w(1 + \tau_{\ell i}) \quad (27)$$

$$MRPK := \nu\alpha \frac{y_i}{k_i} = (r + \delta)(1 + \tau_{ki}) \quad (28)$$

where  $\tau_{\ell i}$  and  $\tau_{ki}$  denote the percent deviation of the marginal products from  $w$  and  $(r + \delta)$  respectively.

In an economy with no financial frictions and no firing costs  $\tau_{\ell i} = \tau_{ki} = 0 \forall i$ . Most studies that analyze the impact of financial frictions assume a frictionless labor market, which in the present model implies  $\tau_{\ell i} = 0 \forall i$ . In the presence of firing costs, this is not the case anymore. Depending on the idiosyncratic state, firms can have MRPL below or above  $w$ . Hence, changes in the dispersion of MRPL are informative of how labor reallocates after a reform. Similarly, in the presence of financial frictions, financially constrained firms will have MRPK higher than  $(r + \delta)$ . Importantly, the level of firing costs will also interact with the dispersion in MRPK.

### 3.5.1 An Economy with Firing Costs

I first analyze the effects of the financial reform in the baseline economy where firing costs are present. Table 11 summarizes the long run effects of the financial reform. Following the reform, TFP increases by 2.5%. This increase is driven by a substantial decrease in the dispersion of the marginal product of capital. This is expected since now the collateral constrained is relaxed and hence firms will be less likely to be financially constrained. There is also an indirect effect that arises when firing costs are present in the economy.

Since firms are less financially constrained, there is an increase in the demand for capital. Since capital and labor are complements, firms also demand more labor. As a result, the wage goes up. This increases the effective cost of firing a worker (recall firing costs are proportional to the wage). Hence, firms who receive good productivity shocks and have low past employment will hire less labor relative to prior the reform, which will in turn make these firms less likely to be financially constrained. This improves the allocation of capital.

Table 11: Aggregate Changes after Financial Reform,  $\tau = 0.5$

Moment	Value
$\% \Delta TFP$	2.5
$\% \Delta S.D. MRPK$	-81.0
$\% \Delta S.D. MRPL$	4.0

The wage increase has a negative effect on the allocation of labor since the effective cost of firing a worker has increased. This generates an increase in the dispersion of the marginal product of labor. However, this effect is not quantitatively large as to offset the effect on TFP of the better allocation of capital.

### 3.5.2 Ignoring Firing Costs

In this section I analyze the effects of the reform if firing costs are ignored from the analysis, and compare the results to the economy with firing costs. To carry out this analysis, I set  $\tau = 0$  and recalibrate the baseline economy so that the credit-to-output ratio is 0.33 as in the Chilean economy. This is achieved by setting the collateral constraint parameter to  $\lambda = 1.4$ . This economy has a standard deviation of  $\log(\ell)$  equal to 3.27. Since there are no firing costs, firms adjust labor more and therefore it becomes more volatile. Capital and labor share of the top 30% are similar to the economy with firing costs.

The counterfactual exercises is the same as in the previous section. That is, I increase the collateral constraint parameter to  $\lambda = 5$ .<sup>35</sup> Table 12 summarizes the impact of the reform on TFP and the allocation of resources. Importantly, in this economy TFP only goes up by 0.3%. There are two reasons driving this difference. First, the indirect effect is not present in the economy with no firing costs. Second, the type of firm that are constrained prior to the reform is different in each economy.

<sup>35</sup>This implies an external credit-to-output ratio of 1.47 after the reform. I also perform the counterfactual where I increase  $\lambda$  so that the external credit-to-output ratio is equal to 1.10, and obtain similar results.

Table 12: Aggregate Changes after Financial Reform,  $\tau = 0.0$

Moment	Value
$\% \Delta TFP$	0.3
$\% \Delta S.D.MRPK$	-77.0
$\% \Delta S.D.MRPL$	0.0

The indirect effect is an important driver of the results. The first row of Table 13 shows the percentage of constrained firms before and after the reform in each economy. Prior to the reform, roughly 14 percent of firms are financially constrained in both economies. This is expected since both are calibrated to have the same external credit-to-GDP ratio. However, after the reform the fraction of constrained firms in the economy with firing costs is 2.67 percent, whereas it is 5.25 percent in the economy with no firing costs. After the reform, firms with good productivity shocks will hire less labor and demand less capital in the economy with firing costs relative to prior the reform. This is triggered by an increase in the effective cost of firing a worker due to an increase in the wage of 8 percent. In the economy with no firing costs, this effect is not present since labor can be costlessly adjusted.<sup>36</sup>

<sup>36</sup>The wage goes up by 15 percent in the economy with no firing costs.

Table 13: Constrained Firms in Both Economies

Moment	Benchmark Economy, $\tau = 0.47$		No Firing Cost Economy, $\tau = 0.0$	
	$\lambda = 1.35$	$\lambda = 5.0$	$\lambda = 1.35$	$\lambda = 5.0$
Collateral Constraint Parameter	$\lambda = 1.35$	$\lambda = 5.0$	$\lambda = 1.35$	$\lambda = 5.0$
% of Financially Constrained Firms	13.77	2.67	13.85	5.25
Share low $z$	0.11	0.00	0.07	0.00

The second row of Table 13 shows the share of firms who receive shocks below the 80th percentile who are financially constrained. This fraction is higher in the economy with firing costs. This is due to the fact that in the presence of firing costs, there are firms that are financially constrained because they hoard too much labor and therefore demand a large amount of capital. Relaxing the problem of this type of firms is important since they have a larger marginal product of capital relative to the economy with no firing costs.

### 3.6 Studying Different Economies

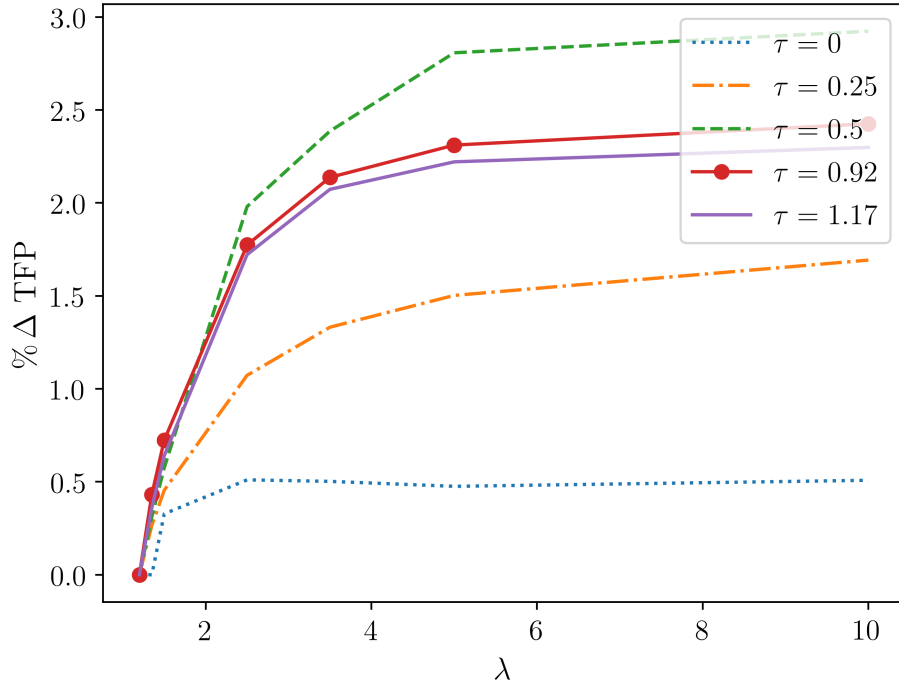
In this section I further explore the interaction between firing costs and financial frictions through two policy experiments. Using the baseline calibration, I first study the effect of relaxing collateral constraints for economies with different levels of firing costs. Interestingly, the elasticity of the wage with respect to the collateral constraint parameter plays a key role in understanding the magnitude of the change in TFP across economies. Second, I study the effects of an increase in firing costs for economies with different levels of financial development. I find that economies with higher level of financial development (i.e. higher  $\lambda$ ) suffer a smaller drop on TFP after an increase in firing costs.<sup>37</sup>

<sup>37</sup>All the results shown below have to be understood as steady states comparison of different economies.

### 3.6.1 Relaxing Collateral Constraints

To examine how firing costs interact with a relaxation of collateral constraints, I do the following policy exercise. I fix all the parameters of the baseline economy and analyze an increase in  $\lambda$  from  $\lambda = 1.20$  to  $\lambda = 10.0$  for economies with different levels of  $\tau$ . This change in the collateral constraint is motivated by the empirical fact that the external credit-to-output ratio ranges from 0.10 to 1.79.<sup>38</sup> This is done for economies with firing costs ranging from  $\tau = 0$  to  $\tau = 1.17$ , which is equivalent to 14 monthly wages.<sup>39</sup> This is the range that Heckman and Pagés (2003) find for countries in Latin America.

Figure 11: Percentage Change in TFP for Different  $\tau$



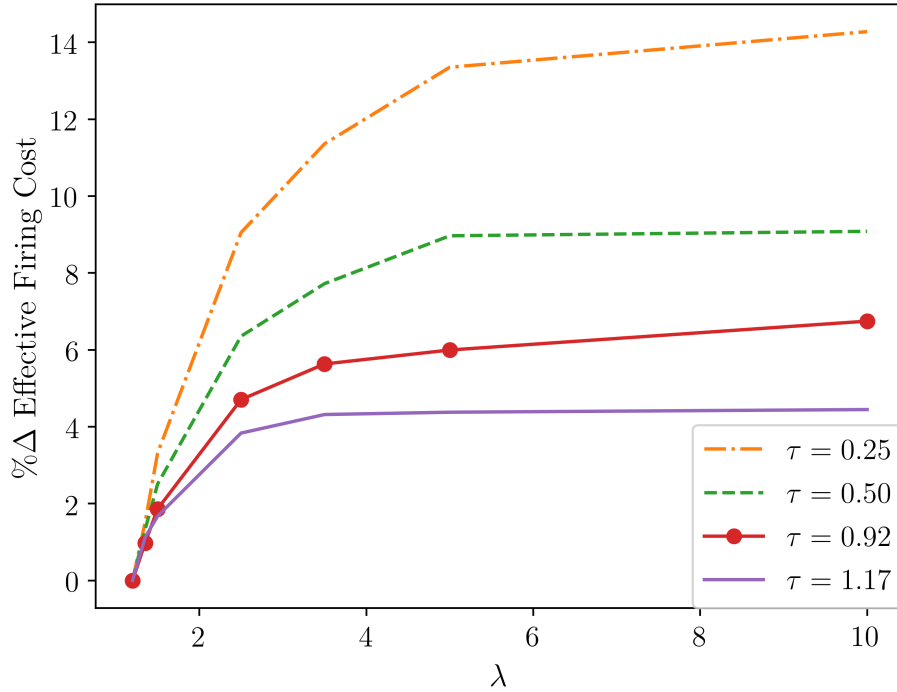
The effect of the change in the collateral constraint on TFP can be seen in Figure 11. There is a non monotonical relationship between the increase in TFP from an increase in  $\lambda$  and the level of the firing cost. This is explained by the increase in the effective cost of firing a worker ( $\tau w$ ) following an increase in the collateral constraint. Figure 12 shows this

<sup>38</sup>This range is taken from the update of 2018 of the Financial Development and Structure Database (See Beck et al. (2000)).

<sup>39</sup>Specifically, I analyze firing costs equivalent to 0, 3, 6, 11 and 14 monthly wages.

change for the economies analyzed.

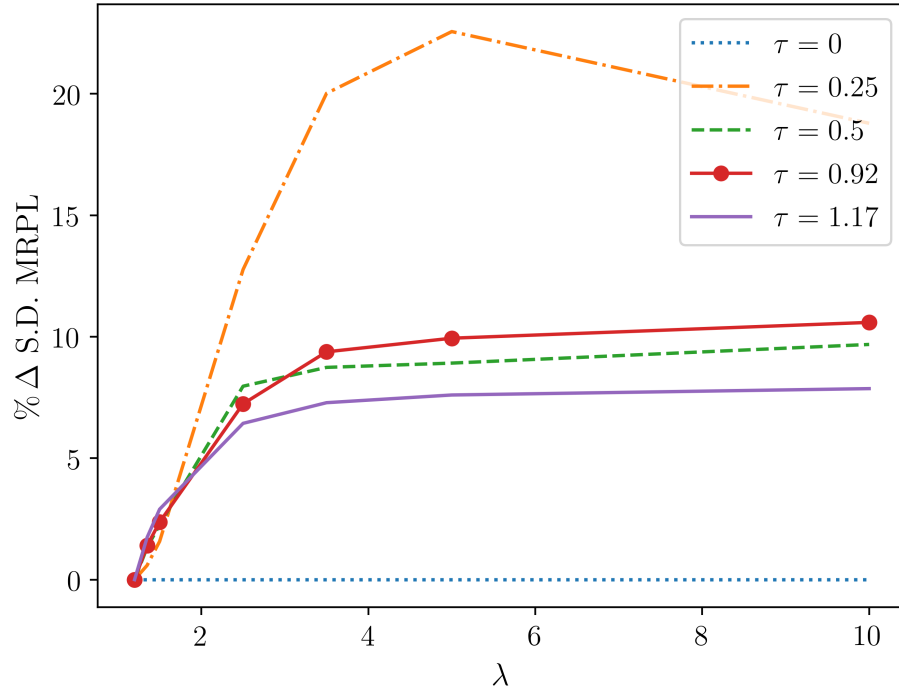
Figure 12: Percentage Change in Effective Cost of Firing for Different  $\tau$



In economies where the firing cost is low, wages go up more since it is less costly to adjust labor and hence firms demand more labor. In economies with high firing costs, the wage does not adjust as much since adjusting labor is too costly, but firing costs were high to begin with. The effective cost of firing increases more in economies with lower firing costs.<sup>40</sup> As a result, the standard deviation of MRPL increases more in such economies as can be seen from Figure 13.

<sup>40</sup>The economy with  $\tau = 0$  is not depicted in the graph since the effective cost of firing in this economy is always 0.

Figure 13: Percentage Change in Standard Deviation of MRPL for Different  $\tau$



Due to the indirect effect explained in the previous section the marginal product of capital drops more in economies with higher levels of  $\tau$ , as can be seen in Figure 14. This is an important driver of the larger increase in TFP for such economies. However, the initial conditions prior to the change in  $\lambda$  are part of the reason why the relation between  $\tau$  and the change in TFP is non monotonic. Table 14 reports the share of constrained firms who receive shocks below the 80th percentile for economies where  $\lambda = 1.20$ . This share first increases and then decreases as  $\tau$  increases. Thus, in economies where  $\tau$  is too low or too high, this share is lower. When  $\tau$  is low, it is relatively cheaper for firms to adjust labor and therefore they fire workers after receiving a bad shock. When  $\tau$  is large, firms remain small and therefore do not hoard labor. Hence, the effect on TFP after an increase in  $\lambda$  through the direct channel is stronger for moderate values of  $\tau$ .

Figure 14: Percentage Change in Standard Deviation of MRPK for Different  $\tau$

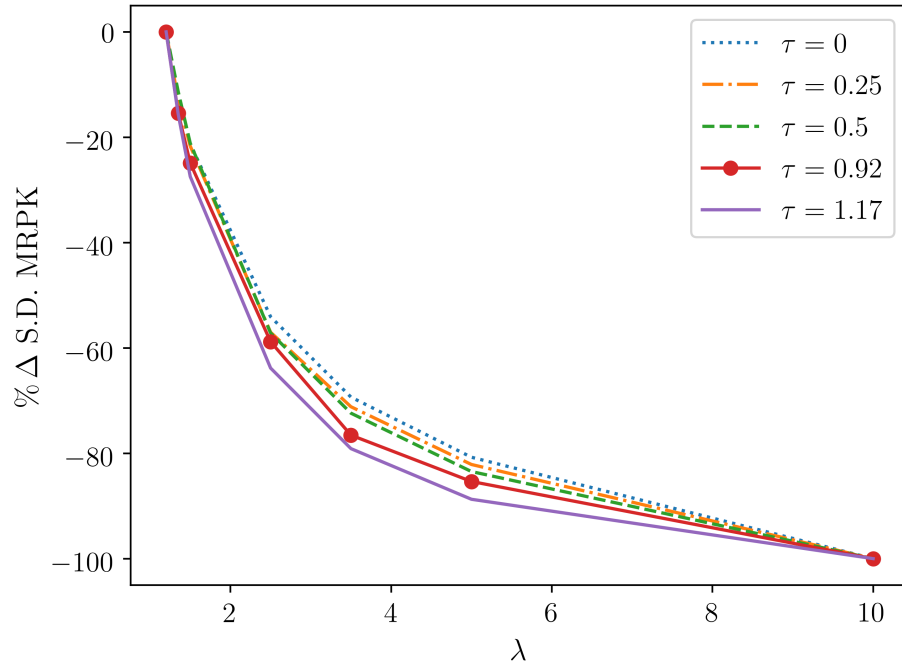


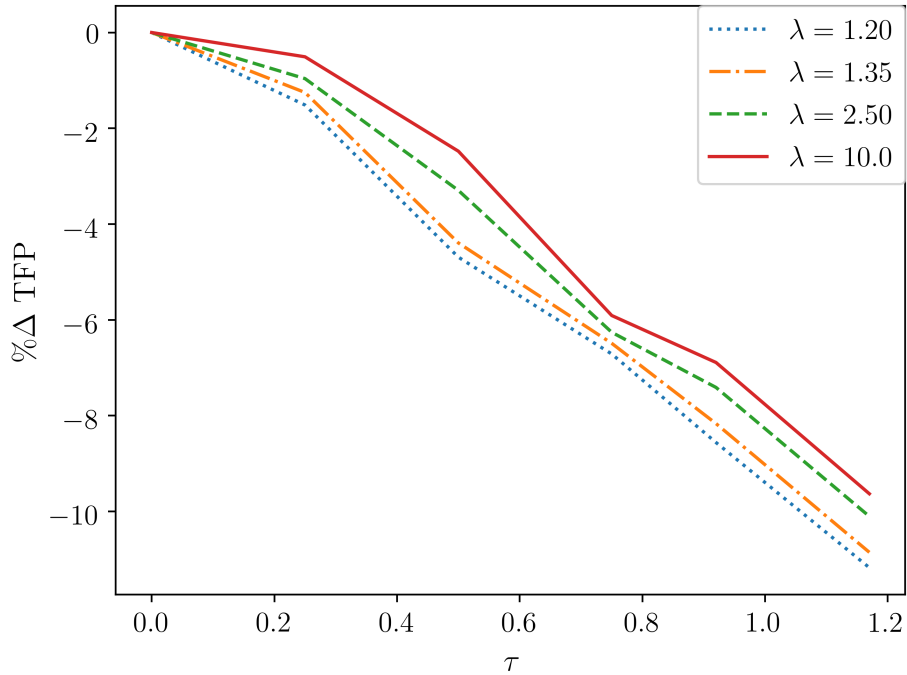
Table 14: Share of Constrained Firms with  $z$  Below 80th Percentile,  $\lambda = 1.20$

Moment	$\tau = 0.0$	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.92$	$\tau = 1.17$
Share constrained firms w/low $z$	0.10	0.15	0.17	0.09	0.07

### 3.6.2 Increasing Firing Costs

In this section I study an increase in the firing cost for economies with different levels of financial development. As in the previous subsection I fix all the parameters to the baseline and increase  $\tau$  from 0 to 1.17 for economies with different levels of  $\lambda$ . The results of this analysis are summarized in Figure 15. There is a monotonic relationship between the drop in TFP after an increase in  $\tau$  and the level of  $\lambda$ . That is, TFP drops less for higher levels of the collateral constraint parameter.

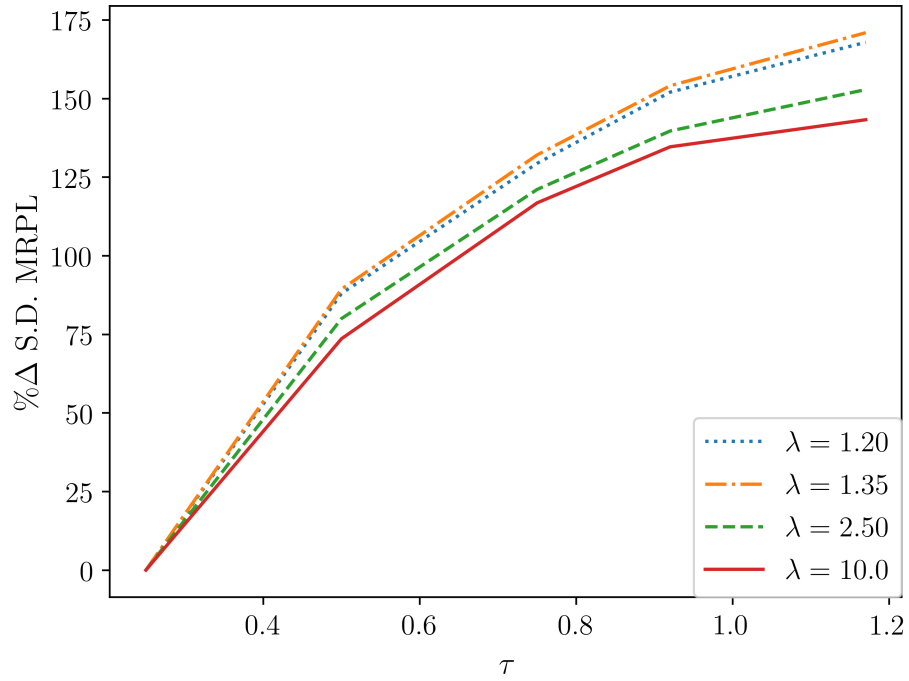
Figure 15: Percentage Change in TFP for Different  $\lambda$



There are two forces driving this result. On one hand, an increase in firing costs worsens the allocation of labor but less so in economies with more developed financial markets. On the other hand, an increase in the firing cost distorts the allocation of capital in economies with financial frictions, but less so in economies where these frictions are less severe.

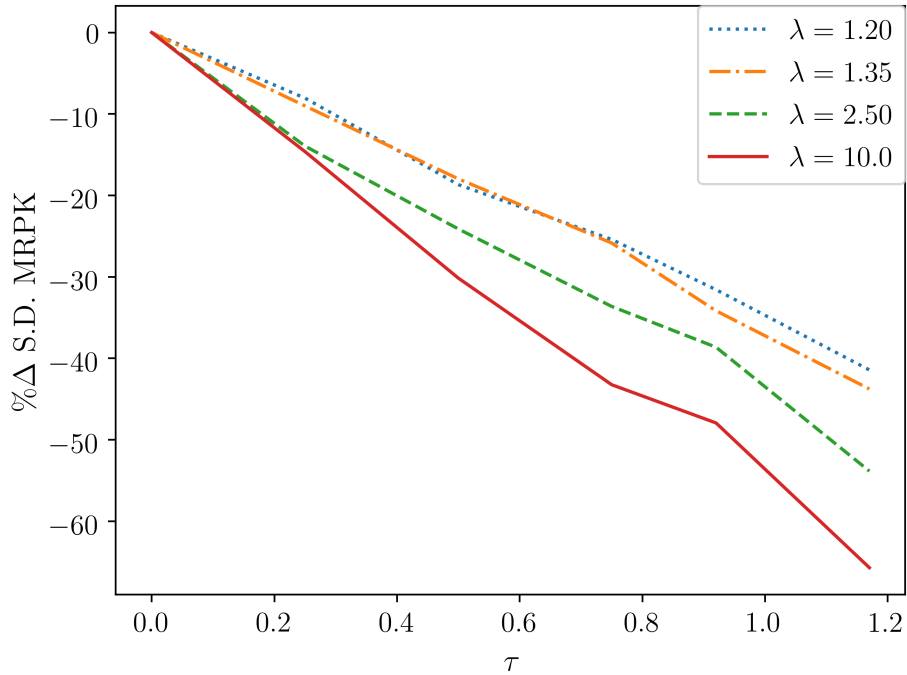
Figure 16 depicts the change in standard deviation of MRPL following an increase in  $\tau$ . Notice that it increases less in economies with higher  $\lambda$ . Hence, labor is relatively less distorted after an increase in firing costs in economies where financial markets are more developed. This is because when the collateral constraint parameter is high, firms do not have to accumulate net worth to relax their financial constraint, and therefore can use some of the internal resources to pay for the firing cost and have a better allocation of labor.

Figure 16: Percentage Change in Standard Deviation of MRPL for Different  $\lambda$



The change in the dispersion of MRPK following an increase in  $\tau$  is shown in Figure 17. The reason why there is a relatively better allocation of capital is that increasing firing costs lowers the size of firms with high productivity shocks, and as a result these firms are less likely to be financially constrained. This effect is stronger in economies where the collateral constraint parameter is higher.

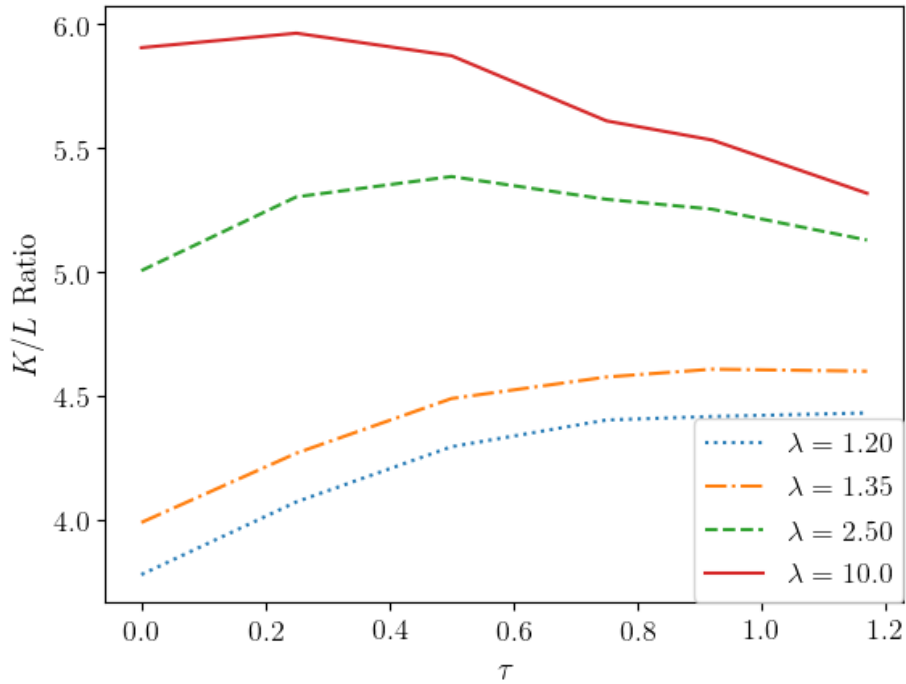
Figure 17: Percentage Change in Standard Deviation of MRPK for Different  $\lambda$



Finally, I explore how the aggregate capital-to-labor ratio changes when firing costs increase in economies with different levels of financial development. I find qualitatively similar results to the empirical literature that analyzes the joint effect of employment protection and financial development on firms' investment. There are studies that find that increasing employment protection generates an increase in the capital-output ratio, and there are studies that find the opposite. The key distinction between these studies is the types of economies they analyze. Autor et al. (2007) find that in the U.S. a small increase in the cost of firing workers (starting from a situation with almost no cost) the capital to labor ratio increases. As can be seen in Figure 18, in economies with high  $\lambda$  there is a slight increase in the capital to labor ratio for moderate changes of  $\tau$  starting from  $\tau = 0$ . Similarly, Cingano et al. (2014) study a small increase in employment protection in Italy in 1990 when firms below the threshold of fifteen employees were no longer exempt from paying severance payments. They also find a positive relation between the capital-labor ratio and the level of employment protection. On the contrary, Calcagnini et al. (2009) and Cingano et al. (2010) find a negative relation between firing costs and capital-labor ratio. These studies make use

of cross country variation in labor protection legislation across European countries. These countries are characterized by highly regulated labor markets and a relatively high level of financial development. Similarly, I find that in economies where  $\lambda$  is relatively high, the capital-labor ratio is decreasing for large levels of the firing cost. Intuitively, increasing  $\tau$  moderately starting from  $\tau = 0$  induces firms to hoard labor and hence demand more capital. However, for larger levels of  $\tau$  is too costly for firms to hoard labor and do not have incentives to grow. Hence firms become smaller and demand less capital.

Figure 18: Aggregate Capital-Labor Ratio for Different  $\lambda$



### 3.7 Conclusion

The goal of this chapter is to study and quantify the impact of the interaction between financial frictions and firing costs. In particular, I study the effect of a financial reform in an economy where firms find it costly to fire workers. To do this, I set up a model with heterogeneous firms that face both firing costs and collateral constraints. I calibrate the model using census plant level data from the manufacturing sector in Chile and aggregate moments. Using the calibrated model, I quantify the long run change in total factor pro-

ductivity after a financial reform. I find that TFP increases by 2.5% following the reform. If firing costs are not taken into account in the analysis, after a financial reform TFP increases by only 0.3%. Acknowledging firing costs is important since it worsens the allocation of capital prior to the reform and hence the reform has a larger impact on productivity. The model can qualitatively replicate certain features of the empirical literature. The impact of firing costs on productivity is smaller in economies with more developed financial markets. Furthermore, the relationship between the capital-labor ratio and the level of firing costs is hump-shaped for certain levels of financial development.

## 4 Conclusion

The objective of this dissertation is to analyze how government policy affects aggregate productivity. In particular, how government policy can affect the way resources are allocated across firms with different levels of productivity, potentially distorting the optimal allocation of resources.

To be able to quantify these effects, regardless of the type of government policy in mind, it is important to have detailed plant level information. Chapter 1 describes the data set used for this purpose. The data set is a plant level census of the manufacturing sector in Chile with very detailed balance sheet and production information. This data set is then used in Chapters 2 and 3 to evaluate different government policies and its effects on aggregate productivity.

In Chapter 2, we study how corporate tax rates affect allocation of resources and aggregate productivity. 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 productivity even within narrowly defined industries. As a result, effective corporate tax rates can potentially generate an inefficient allocation of resources across firms, which directly affects total factor productivity. We document this dispersion using the data described in Chapter 1. We then develop a monopolistic competition model that incorporates these findings to quantify the effects of corporate tax rates in aggregate productivity.

Finally, in Chapter 3, I study the interaction between financial frictions and firing costs and its impact on aggregate productivity. To do this, I develop a small open economy model with heterogeneous firms that face collateral constraints and have to pay firing costs. I calibrate the model using the data described in Chapter 1. I find that aggregate productivity increases by 2.5 percent following a financial reform that makes Chile's level of financial development comparable to that of the United Kingdom. Ignoring firing costs underestimates the impact of the reform, predicting an increase in productivity of 0.3 percent. Acknowledging firing costs introduces two reasons why the financial reform has a stronger impact. First, firms with high past employment hoard labor and, as a result, demand more capital, which makes them more likely to be financially constrained. Second, an increase in wages following the reform increases the effective firing cost and hence discourages firms with low

past employment from hiring. As a result, these firms demand less capital than they would if there were no firing costs and are less likely to be financially constrained. Finally, I study the effect on productivity of the interaction between these two frictions when evaluating labor and financial reforms. I do this for a range of economies with plausible initial levels of financial development and firing costs.

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# Appendix

## A Chapter 2 Appendix

### A.1 Data Base Creation

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 15 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 15: 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.

## A.2 Sensitivity Analysis

Table 16: Output gap decomposition: Hours as Labor Input,  $t_{si} = 0$  (percent)

Year	Output Gap	TFP Gap	Intersectoral	Intersectoral	$\Delta$ Aggregate
			$K$	$L$	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

### A.3 Robustness Checks on the Measurement of Effective Tax Rates

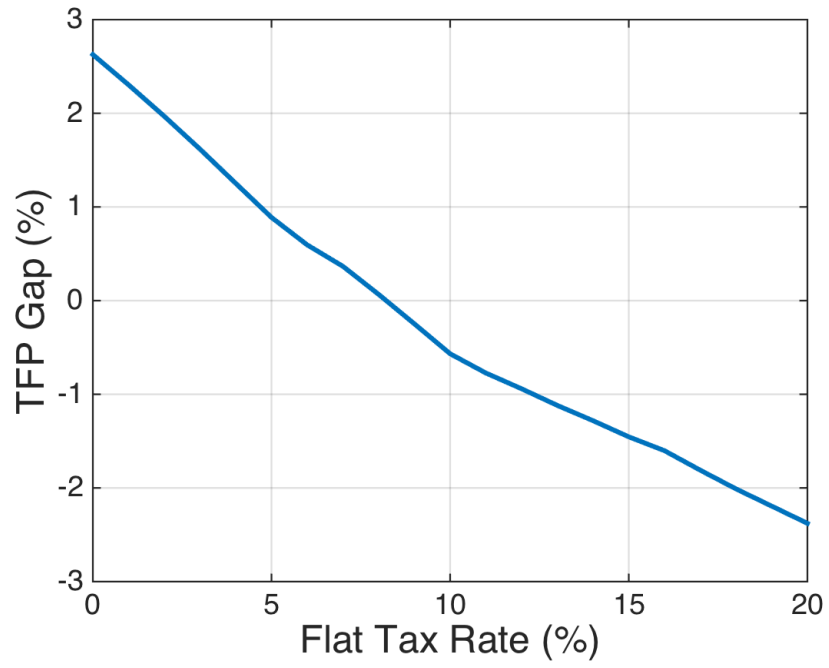
Table 17: Output gap decomposition: Loss Carryforward,  $t_{si} = 0$  (percent)

Output Gap	TFP Gap	Intersectoral	Intersectoral	$\Delta$ Aggregate
		$K$	$L$	Capital
22.99	6.18	0.78	0.74	15.30

Table 18: Distribution of Effective Profit Tax Rates: Permanent Sample (percent)

Year	25th percentile	50th percentile	75th percentile	90th percentile	Statutory Tax Rate	Standard Deviation
2003	2.75	14.46	17.16	24.11	16.5	12.53
2004	8.30	15.56	17.39	22.41	17	11.06
2005	8.43	15.83	17.44	22.36	17	11.52
2006	7.85	15.63	17.31	22.71	17	10.38
2007	8.16	15.87	17.65	24.40	17	13.05

Figure 19: Relationship between TFP Gap and  $\bar{t}$ : Permanent Sample (2003)



## B Chapter 3 Appendix

### B.1 Span of Control Parameter

Table 19: Values of Span of Control Parameter for Chile 1995-2007

Moment	Value
Min	0.75
Max	1.03
Median	0.85
Mean	0.88
Variance	0.09

Source: authors calculations using the ENIA for the years 1996 to 2007.

Note: Values are calculated by summing the elasticities resulting from the production function estimation using Wooldridge (2009) method.