Spatial Misallocation across Chinese Firms

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September 14, 2017

Abstract

We develop a general equilibrium framework to quantify the welfare implications of firm-level frictions in China. We use individual firm data to estimate output and labor frictions for each city and for state-owned and private firms separately. We find that the existing frictions favor the SOEs over the private firms, and exert a 13 percent aggregate welfare loss in 2007. The spatial disparity of the frictions lowers the aggregate welfare by 1.27 percent, while increases the spatial inequality by 5 percent. Between 1998 and 2007 the firm-level frictions worsened and lowered the aggregate welfare by around 0.3 percent per year.

Keywords: misallocation; regional trade; economic geography; welfare gain

JEL Classification: F12;O11;R12

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1 Introduction

Frictions at the micro-economic level can be costly: they affect firm-level decisions, distort the resource allocation, and eventually might lower the aggregate productivity.[1] Oftentimes laws and regulations vary across regions, and national policies are mostly implemented by local governments that differ in their institutional efficiencies, the frictions are thus location-specific within a country. The spatial dimension of the micro-level frictions in turn influences the distribution of economic activities across regions; the resulting spatial misallocation of resources might lower the aggregate productivity and welfare, and simultaneously amplify the spatial inequality. In this paper we explore the spatial dimension of the micro-level frictions in the case of China: we first estimate the firm-level frictions and show that they vary substantially across cities and regions. We then quantify their macro-economic implications through a general equilibrium framework, and show that the spatial disparity of the frictions lowers the aggregate welfare and meanwhile amplifies the spatial inequality.

We incorporate the empirical framework of Hsieh and Klenow (2009) into a quantitative trade model following the ideas of Melitz (2003), Eaton et al. (2011), and Di Giovanni and Levchenko (2012). Our model allows for heterogeneous firms, inter-city trade, and endogenous firm entry and exit decisions. Firm size distribution, real wage, and internal trade volume are all endogenously determined in the general equilibrium. This allows micro-level frictions to manifest themselves in the aggregate outcomes through multiple channels.

We introduce two types of frictions: 1) output friction that directly affects firm's sales revenue and 2) labor friction that only affects the relative costs of labor faced by a firm. We interpret the micro-frictions as outcomes of policy regulations on the goods and labor markets, corporate governance mis-practices, and limited access to the infrastructure and financial markets. The frictions in the model are isomorphic to taxes or subsidies on the firms' sales revenue and payroll; we thus use the implied tax revenue or deficit on the government's budget as the measure of the size of the distortions in the quantitative exercises. The frictions depend on both the location and the ownership of the firm: state-owned enterprises (SOE)

[1] See Restuccia and Rogerson (2008), Hsieh and Klenow (2009), Francisco et al. (2011) and Midrigan and Xu (2014) among others for examples.

or the private firms.[2] Distinguishing between SOEs and private firms is important in our context, as they often adopt different corporate governance practices and receive differential treatments in the financial/labor markets.[3] In addition, the property of SOEs varies across cities, which directly contributes to the spatial variations of the frictions. We use firm-level data from the *Annual Surveys of Industrial Firms* to estimate the output and labor frictions in each firm following Hsieh and Klenow (2009). We then aggregate the frictions up to the city-level separately for state-owned and private firms, and repeat this exercise for each year between 1998 and 2007.

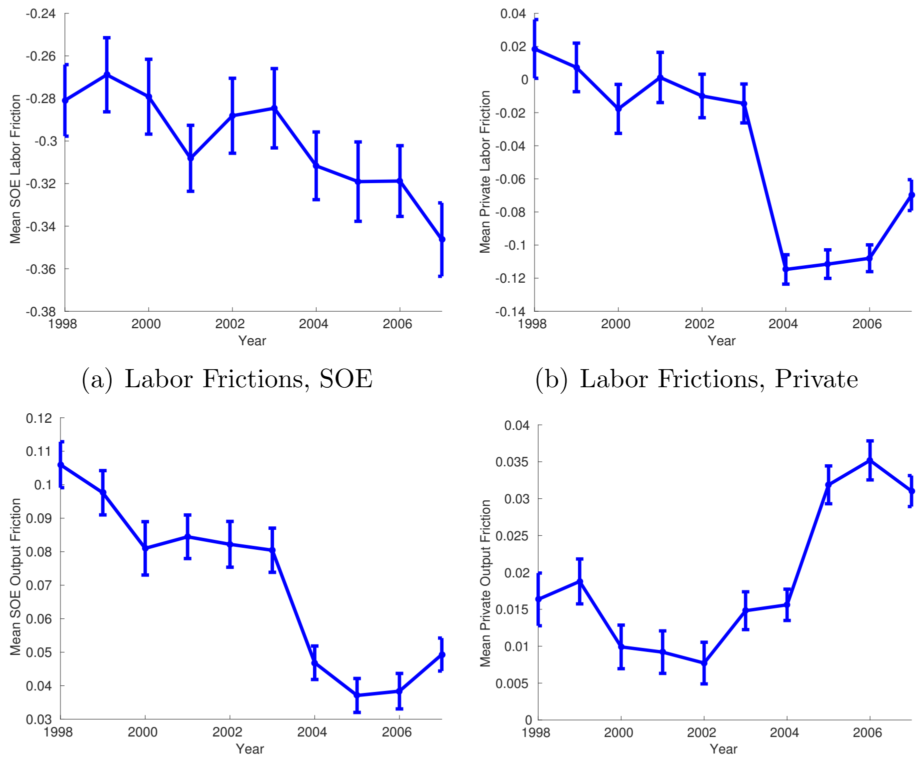
Figure 1.1 summarizes the estimated frictions over time. Both types of firms receive large and increasing subsidies in term of labor utilization, and the relative costs of labor are significantly higher for private firms compared to the SOEs. The estimated labor frictions vary between -0.28 and -0.34 over the years, which implies that the SOEs have received subsidies equivalent to around 1/3 of their payroll. In contrast, labor frictions among private firms were not significantly different from zero before 2004, and only dropped to -0.07 in 2007. Output frictions stay positive for both types of firms throughout the years, indicating the existence of policies or organizational inefficiencies that restrict the size of the firms. The frictions among SOEs are always higher than those of the private firms: in 1998 the gap between them was equivalent to an additional 9-percent revenue tax against SOEs; over the years the gap shrank, but was still equivalent to an additional 2-percent tax by 2007.

The estimated frictions suggest that labor, a critical resource in the economy, was inefficiently allocated towards the SOEs. The SOEs enjoy higher labor subsidies, which draw workers away from the private sector. Unfortunately, meanwhile they also suffer from higher output frictions, which implies that they are less productive as compared to the private firms. We find that removing all the frictions indeed induces labor reallocation to the private sector, which in turn is responsible for a sizable welfare gain in the quantitative exercise.

The frictions also vary substantially across space, as shown in Figure 1.2 and Table 2 and 3. Overall, larger cities are less distorted than smaller ones. Labor frictions are closer to zero in larger cities for both types of firms. As in most cities the labor frictions are

[2] Throughout the paper, we use "non-state firms" and "private firms" interchangeably.

[3] For the differences in organization and corporate governance, see Qian (2000), Firth et al. (2006), and Mengistae and Xu (2004). For the differences in market access, see Song et al. (2011).



(a) Labor Frictions, SOE (b) Labor Frictions, Private

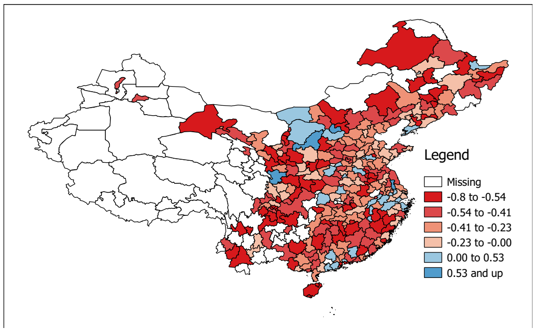
(c) Output Frictions, SOE (d) Output Frictions, Private

Figure 1.1: Labor and Output Frictions over Time

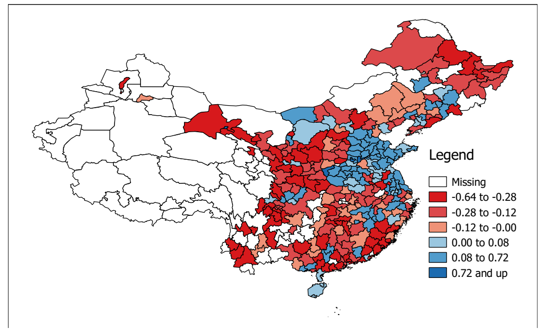
Notes: The graphs present the average labor and output frictions across the entire country between 1998 and 2007. The error bars indicate a 95-percent confidence interval, and the standard errors are estimated with bootstrapping.

negative, this implies that the measured labor subsidies are smaller in larger cities. The output frictions, especially among the private firms, are closer to zero in larger cities as well, making them more productive than smaller cities. The same pattern can be observed across broader regions as well: richer and larger cities along the Eastern coast have advantages in output frictions among the private firms, while smaller and poorer cities in the Western part of the country have significantly higher output and labor distortions. The spatial pattern of the distortions implies that removing the frictions can potentially lower spatial inequality, as smaller and poorer cities seem to suffer more from the existing frictions.

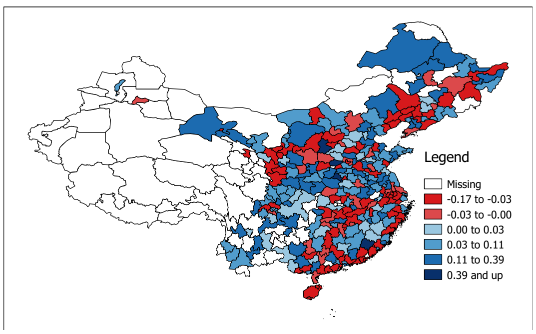
We quantify the welfare implications of the frictions through a general equilibrium model. The model is calibrated to 279 prefecture-level cities in China in 2007. The structural parameters are chosen to match the moments in the firm-size distribution, internal trade volume, and the fraction of state-owned firms in the data. We also take into account the relative



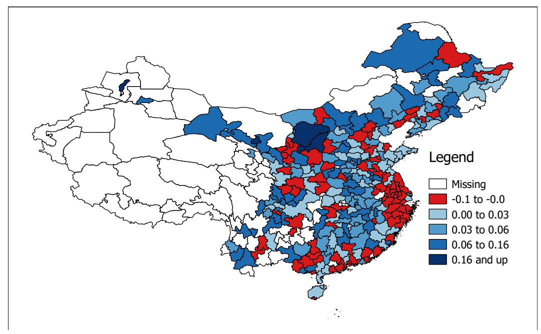
(a) Labor Frictions, SOE



(b) Labor Frictions, Private



(c) Output Frictions, SOE



(d) Output Frictions, Private

Figure 1.2: Labor and Output Frictions over Space

Note: The figures here plot the estimated frictions by city and ownership in 2007. For details of the estimation, see the main text.

positions of the cities in the transportation network following Allen and Arkolakis (2014) and Ma and Tang (2016). The geographic components capture the spillover effects: changes in frictions of one city affect all the other cities via inter-city trade, and the magnitude depends on the traffic network. Our benchmark calibration successfully matches several key un-targeted moments in the data, such as the distribution of city size and the number of operating firms.

We perform several counter-factual experiments to evaluate the welfare impacts of the frictions. Eliminating all the frictions in year 2007 leads to a 13 percent increase in aggregate welfare, a 14.7 percent labor re-allocation toward the private sectors, and a 14.9 percent decline in the number of operating SOEs. The welfare gain can be decomposed into several channels. As mentioned above, the existing frictions favor the less efficient SOEs. We run a set of counter-factual analysis in which we eliminate the differences in frictions between the SOEs and the private firms while maintaining the average level of frictions in each city.

The resulting labor reallocation towards the private firms is identical to the frictionless case, and it increases the aggregate welfare by 4.4 percent, or around $4.4/13 \approx 34.2$ percent of the overall welfare gain from the complete elimination of the frictions.

The existing frictions also distort firm entry and exit, which in turn affects the number of varieties available to the consumers and the ideal price index in each city. To single out the effects of the extensive margin, we simulate the model in a frictionless economy while keeping the number of firms in each city-ownership cell to its baseline value in 2007. The elimination of frictions only improves welfare by 2.48 percent in this case, which implies that around $1 - 2.48/13 \approx 80.9$ percent of the gain in welfare can be explained by the changes in the number of firms.

The spatial differences of the frictions also lower aggregate output by distorting the distribution of economic activities across cities. We eliminate the spatial disparity by setting the labor and output frictions in all the cities to their national average, while maintaining the differences between the SOEs and the private firms. This results in a 1.27 percent gain in the aggregate welfare, or $1.27/13 \approx 9.8$ percent of the overall gain. Similarly, equalizing the frictions across cities also leads to 5 percent reduction of spatial inequality, measured as the coefficient of variation or standard deviation of the logarithm of city-level real income, as smaller cities benefit more from the reform than those larger ones.

Mapping all the output and labor frictions to tax- and subsidy-equivalents, the size of the distortions takes around 20 percent of the total GDP in the benchmark simulation. Labor subsidies have significantly contributed to the distortions, while the size of the output frictions is only one-tenth of the labor frictions. As a result, removing all the labor frictions improves the aggregate welfare by 8.17 percent, while removing all the output frictions only improves welfare by 2.14 percent. The frictions among SOEs and the private firms are roughly equal in size. However, eliminating all the frictions among the SOEs improves the overall welfare by 7.75 percent, whereas doing so among the private firms only improves welfare by 2.01 percent. Unilaterally reforming the private sectors is ineffective, because removing the labor subsidies among the private firms serves to strengthen the existing advantage in labor costs of SOEs over the private firms, which further diverts workers away from the private sector.

We also evaluate the impacts of the frictions along the time dimension by comparing our baseline model with a counter-factual case based on the estimated frictions in 1998. Between 1998 and 2007, the size of the distortions has increased from 10.8 percent to 20.1 percent of the GDP. The distortions in 2007 are also more biased toward the SOEs, resulting in a 32 percent increase in the average size of the SOEs and a 8.2 percent decrease in the average size of the private firms. As a result, the real income has decreased by around 2.6 percent between 1998 and 2007, or 0.3 percent per year. The expansion of SOEs and the shrinkage of private firms are perhaps the results of the new waves of reforms in the late 1990s collectively known as "grasp the large and let go of the small" (Zhua Da Fang Xiao), in which many small SOEs are privatized and the remaining large SOEs incorporated. The deterioration of the private firms, on the other hand, is probably the side-effect of the reforms as well, since the reformed SOEs increase competition in both the product and the labor markets.

Our paper is most closely related to the literature on micro-level frictions and resource misallocation. Restuccia and Rogerson (2008) argue that differences in the allocation of resources across heterogeneous firms may be an important factor in accounting for cross-country differences in per-capita output. Hsieh and Klenow (2009) propose an empirical strategy to estimate the micro-level frictions, and show they have resulted in sizable loss in productivity in the case China and India as compared to the US. Francisco et al. (2011) examine the role of financial frictions in explaining the differences in aggregate productivity across countries. Guner et al. (2008) study the size-dependent policies on capital and labor. They find that the policies that restrict the size of the firms can lead to a costly adoption of new technology. Yang (2016) highlights the importance of firm's entry and exit decisions on the aggregate implications of micro-level frictions. Hopenhayn (2014) provides theoretical foundations for the link between firm-level distortions and aggregate productivity. In the context of China, Tombe and Zhu (2015) study how misallocation due to goods and labor market frictions affect aggregate productivity at the province level. Brandt et al. (2013) measure the reduction in aggregate non-agricultural TFP due to labor and capital distortions across provinces and sectors for the period 1985-2007.

We contribute to this literature in the following aspects. On the theoretical side, we introduce a new quantitative framework that incorporates internal trade and firm entry/exit decisions into a model that allows for the estimation of frictions. We show that these new factors are critical in driving the welfare implications of frictions, and are straightforward to implement quantitatively. Our model also takes the general equilibrium effects on price levels into consideration, which in turn allows us to study the welfare impacts of frictions in addition to TFP. On the empirical side, our paper is the first to estimate the frictions at the city level in China. We show that the micro-frictions vary systematically across cities and the spatial distribution of the distortions affects both the aggregate welfare and the spatial inequality.

Our work is broadly related to the large body of literature on the Chinese economy. Brandt et al. (2008) document the process of industrial transformation and the role played by institutions and barriers to factor allocation. Song et al. (2011) argue that the reduction in the distortions associated with state-owned enterprises may be responsible for the rapid economic growth since 1992. Hsieh and Song (2015) use firm-level data to show that the reforms of the state sector were responsible for 20 percent of aggregate TFP growth from 1998 to 2007. Our work complements this literature. We show that the favorable treatment toward state-owned firms mainly exists in the labor market. In addition, the frictions and favoritism toward the SOEs deteriorated over time, leading to aggregate welfare loss between 1998 and 2007.

The rest of this paper is organized as follows: Section 2 presents the theoretical framework. We discuss the estimation strategies in Section 3. Section 4 presents the calibration strategy, and Section 5 describes the quantitative results. Section 6 concludes.

2 The Model

We introduce labor and output frictions following Hsieh and Klenow (2009) into a multi-sector, multi-city framework with trade, heterogeneous firms, and endogenous firm entry/exit decisions similar to Di Giovanni and Levchenko (2012).

The economy contains a mass $\bar{L}$ of identical workers living in $J > 1$ geographically segmented cities, indexed by $j = 1, 2...J$. We denote the population in city j as L_j, and do not allow workers to move across cities. Workers in city j obtain utilities from consuming the set of varieties available in the city:

$$U_j = \left[\sum_{k \in \Omega_j} y\left(k\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon}{\varepsilon-1}},$$

where ε represents the elasticity of substitution across all varieties, $y(k)$ denotes the consumption of variety k, and Ω_j denotes the set of available varieties in city j.

Each variety is produced by a single firm in a monopolistic competitive market. The production of each variety requires "input bundles", which in turn uses local labor and all the locally available varieties to produce. Hereafter, we call the available varieties in city j the *composite varieties* and denote them as Y_j. Specifically, the production function $F(\cdot)$ for the input bundle in city j takes the standard Cobb-Douglas form:

$$F(L_j, Y_j) = L_j^{\beta} Y_j^{1-\beta} = L_j^{\beta} \left[\sum_{k \in \Omega_j} y\left(k\right)^{\frac{\varepsilon-1}{\varepsilon}} \right]^{\frac{\varepsilon(1-\beta)}{\varepsilon-1}},$$

where $\beta \in (0, 1)$ denotes the labor share of production and $1 - \beta$ denotes the share of composite varieties.

Firms are heterogeneous in terms of their input bundle requirements: high productivity firms need fewer input bundles to produce one unit of output. Firms realize their input bundle requirements after they pay the entry costs measured in the units of input bundles, which we denote as f_e.[4] Upon entry, firms draw the input bundle requirement a from a Type-I Pareto distribution with the cumulative distribution function $G(1/a)$:

$$G(\frac{1}{a}) = 1 - \left(a\mu\right)^{\theta},$$

where θ is the tail index and μ captures the lower bound of the firm productivity distribution.

Two types of firms exist in the economy: state-owned enterprises and private firms. Firms do not know their types prior to entry. Upon entry, they draw their productivity and type independently at the same time. With probability $\lambda \in [0, 1]$, the firm becomes state-owned,

[4]The quantity requirement of input bundles for the entry cost is identical across all the cities. However, as the price of input bundles differs across cities in equilibrium, the entry costs will differ in value.

which we denote as S, and with probability $1-\lambda$, the firm becomes private, which we denote as N.

Frictions

We follow Hsieh and Klenow (2009) and introduce two types of frictions to the economy: labor frictions and output frictions. For the ease of quantification, we assume that these frictions only vary at the city ownership level. The simplification is mostly innocuous: most of the frictions in the real world are determined by policies, institutions, and infrastructure, which generally only vary across cities and types of firms.

We define the frictions that affect the marginal product of labor relative to composite varieties as the "labor frictions", or τ_ℓ. Intuitively, a firm needs to pay $(1+\tau_\ell)$ times of the market wage rate to hire one unit of labor input in its production function. τ_ℓ can be results of a payroll tax/subsidy, or the inefficiencies either rooted in the local labor market or organizational structure of the firm. Regardless of their origin, the labor frictions defined above will be directly reflected in the costs of one unit of input bundle for type-d firms in city j:

$$c_j^d = \frac{1}{1-\beta}\left(\frac{1-\beta}{\beta}\right)^{\beta}\left[\left(1+\tau_{\ell,j}^d\right)w_j\right]^{\beta}P_j^{1-\beta}, \quad d=\{S,N\},$$

where w_j is the market wage rate and P_j is the price of composite variety in city j. The above result can be obtained by solving the cost minimization problem in which the firm perceives the unit cost of labor as $(1+\tau_{\ell,j}^d)w_j$. We allow the frictions to be negative, which implies a subsidy on labor inputs. Labor frictions affect the composition of cost-minimizing inputs of the firm, but not necessarily the size of the firm.

We denote frictions that directly affect the firm's revenue as "output frictions," or τ_y. The output frictions directly take a "hair-cut" on the revenue of firm k:

$$\pi_j^d(k) = \left(1-\tau_{y,j}^d\right)\sum_{i=1}^{J} p_i^d\left(k\right)q_i\left(k\right) - a\left(k\right)c_j^d\sum_{i=1}^{J} t_{ij}q_i\left(k\right),$$

where $\sum_{i=1}^{J} p_i^d\left(k\right)q_i\left(k\right)$ is the firm's sales revenue. A positive τ_y results in a wedge between the outputs and sales revenue of the firm: the firm can only receive a fraction $(1-\tau_y)$ of the total sales revenue from the market. We interpret the output frictions as results of revenue tax/subsidy, or policies that excessively regulate the product market, or institutional inefficiencies such as the lack of contract enforcement or rule of law. The output frictions distort the size of the firm, but do not alter the input-sourcing decisions of the firm. Indirectly, they also affect the entry/exit decision: high output frictions will deter entrance as the potential firms need to draw higher productivity to overcome the entry barriers.

As the frictions are isomorphic to payroll and revenue taxes/subsidies, we directly treat them as so to close the model. Positive labor or output frictions lead to tax revenue to the government, and negative frictions lead to deficit on the government budget. We assume that government budget must be balanced locally through lump-sum taxation or transfer payment. The lump-sum taxation and transfer affects the budget constraints of the local workers, and thus alter the general equilibrium outcomes, as we will discuss later in the section. In the quantification part we use the size of the lump-sum transfer/taxation to measure the size of the distortions: everything else being equal, a more distorted economy would feature higher budget-to-output ratio.

2.1 Firm's decision

Denote X_i to be the total expenditure on composite variety in city i. The standard CES utility function yields the following demand function for goods k in city i:

$$q_i\left(k\right) = \frac{X_i}{P_i^{1-\varepsilon}} p_i(k)^{-\varepsilon},$$

where $p_i(k)$ is the price for goods k sold in city i, and P_i is the ideal price index.

Standard results from heterogeneous firm models following Melitz (2003) can be derived with simple modifications. A type-d firm located in city j with input requirement a will solve the following profit maximization problem to determine if it is profitable to sell to city

i:

$$\max_{p_i^d(k)} \quad \left(1-\tau_{y,j}^d\right) p_i^d\left(k\right) q_i\left(k\right) \quad - \quad a\left(k\right) t_{ij} q_i\left(k\right) c_j^d - f_{ij} c_j^d$$
$$s.t. \quad q_i\left(k\right) \quad = \quad \frac{X_i}{P_i^{1-\varepsilon}} p_i^d(k)^{-\varepsilon}.$$

The firm will only do so when the profit is non-negative:

$$\pi_{ij}^d\left(k\right) \quad = \quad \frac{1}{\varepsilon}\frac{\left(1-\tau_{y,j}^d\right) X_i}{P_i^{1-\varepsilon}}\left(\frac{\varepsilon}{\varepsilon-1}\frac{t_{ij} c_j^d a\left(k\right)}{1-\tau_{y,j}^d}\right)^{1-\varepsilon} - f_{ij} c_j^d \geq 0,$$

and will charge the price:

$$p_{ij}^d(k) = \frac{\varepsilon}{\varepsilon-1}\frac{t_{ij} c_j^d a\left(k\right)}{1-\tau_{y,j}^d}.$$

As a result, there exists a cutoff on unit requirements a_{ij}^d above which firm in city j will not serve city i:

$$a_{ij}^d = \frac{\varepsilon-1}{\varepsilon}\frac{\left(1-\tau_{y,j}^d\right) P_i}{t_{ij} c_j^d}\left[\frac{\left(1-\tau_{y,j}^d\right) X_i}{\varepsilon c_j^d f_{ij}}\right]^{\frac{1}{\varepsilon-1}}.$$

We denote the number of type-d firms entering city j as I_j^d. The total number of varieties in city i equals the number of firms that decide to sell to city i from all the cities:

$$\sum_{j=1}^{J}\sum_{d=S,N} I_j^d \cdot \text{Prob}\left(a_{ij}\left(k\right) \leq a_{ij}^d\right).$$

There are infinitely many potential firms in each city and that entering firms can freely exit the market. The free-entry condition implies that in equilibrium, the expected profit from entry should equal the entry costs in each city:

$$\lambda \sum_{i=1}^{J} \mathbf{E}\left[\pi_{ij}^S\left(a\right) \middle| a < a_{ij}^S\right] + \left(1-\lambda\right) \sum_{i=1}^{J} \mathbf{E}\left[\pi_{ij}^N\left(a\right) \middle| a < a_{ij}^N\right] = f_e \bar{c}_j, \qquad (1)$$

where the expectation is taken over the potential realizations of a. The first part of equation (1) is the expected profit from becoming a state-owned firm, whereas the second part is the expected profit of a non-state firm. $\bar{c}_j$ is the unit cost of un-distorted input bundle at the entry stage:

$$\bar{c}_j = \frac{1}{1-\beta}\left(\frac{1-\beta}{\beta}\right)^{\beta} w_j^{\beta} P_j^{1-\beta}.$$

Finally, the ideal price index for composite variety in city i can be obtained as:

$$P_i^{1-\varepsilon} = \sum_{j=1}^{J}\sum_{d=S,N}\left(\frac{\varepsilon}{\varepsilon-1}\frac{t_{ij}c_j^d}{1-\tau_{y,j}^d}\right)^{1-\varepsilon} I_j^d \cdot \text{Prob}(a \leq a_{ij}^d)\cdot \mathbf{E}\left[a^{1-\varepsilon}\middle| a < a_{ij}^d\right].$$

2.2 Equilibrium

Definition: Conditional on a series of fixed costs, entry costs, and iceberg trade costs, $\{f_{ij}, f_e, t_{ij}\}$ and city-type specific frictions $\{\tau_{\ell,j}^S, \tau_{y,j}^S, \tau_{\ell,j}^N, \tau_{y,j}^N\}$, the equilibrium contains a series of values $\{X_j^S, X_j^N\}_{j=1}^J$, a series of prices $\{w_j, P_j\}_{j=1}^J$ and a sequence of quantities $\{I_j^S, I_j^N, L_j^S, L_j^N\}_{j=1}^J$ such that the following conditions hold:

1. Workers maximize their utilities by choosing final goods consumption.
2. Firms maximize their profit by choosing the quantity to sell to each market and the price for the variety.
3. The free entry condition holds in each city.
4. Trade balance:

$$X_j = Y_j + (1-\beta)\left[(1-\tau_{y,j}^S)X_j^S + (1-\tau_{y,j}^N)X_j^N\right].$$

   where Y_j is the disposable income after the lump-sum transfer or taxation:

$$Y_j = w_j L_j + \sum_{d=S,N}\tau_{l,j}^d w_j L_j^d + \sum_{d=S,N}\tau_{y,j}^d X_j^d,$$

5. The labor market clears in each city:

$$L_j^S + L_j^N + (I_j^S + I_j^N)\times f_e \times \left(\frac{P_j}{w_j}\right)^{1-\beta}\cdot\left(\frac{\beta}{1-\beta}\right)^{1-\beta} = L_j,$$

where:

$$L_j^d = \left[\frac{(1+\tau_{\ell,j})w_j}{P_j}\frac{1-\beta}{\beta}\right]^{\beta-1} I_j^d \left[\Omega_j \sum_{i=1}^{J} \frac{X_i}{P_i^{1-\epsilon}}\tau_{ij}^{1-\epsilon}(a_{ij}^d)^{1-\epsilon+\theta} + \sum_{i=1}^{J} f_{ij}(\mu a_{ij}^d)^{\theta}\right], d = S, N$$

$$\Omega_j = \left(\frac{\epsilon}{\epsilon-1}\frac{c_j^d}{1-\tau_{y,j}^d}\right)^{-\epsilon}\mu^{\theta}\frac{\theta}{1-\epsilon+\theta}.$$

Appendix A provides more details on solving the model.

3 Estimating the Frictions

In this section, we start by estimating the frictions using firm-level data, and then aggregate up to the city-sector level and map them to their model counter-parts. We repeat this exercise for each year between 1998 and 2007 to trace the evolution of frictions over time.

3.1 Data

Our firm-level data come from the *Annual Surveys of Industrial Firms* ("*Annual Surveys*" thereafter) conducted by the National Bureau of Statistics (NBS) in each year. The survey covers all the state-owned firms and the private firms with more than 5 million RMB in annual sales. There are on average 216.1 thousand firms in the survey in each year. We define the state-owned firms as those registered as "State-Owned Enterprises", "State Joint Ownership Enterprises", "Joint State-Collective Enterprises", "Wholly State-Owned Enterprises", or joint ventures with more than 50 percent state ownership.

We identify the location of the firms by zip codes and restrict our analysis to those located in the 279 prefecture-level cities that are included in both the *Chinese City Statistical Yearbooks* and the *Chinese 1-percent Population Survey* carried out in 2005, which we later use to calibrate the model. Figure 3.1 depicts the cities in our sample. The sample of cities is representative, as it covers more than 98 percent of the total population and 99 percent of the GDP. The number of firms that are located in these cities comprise approximately 98.1 percent of the entire sample in the *Annual Surveys* as well.

We first cleanse the data by several standard procedures. We drop the firms whose sales

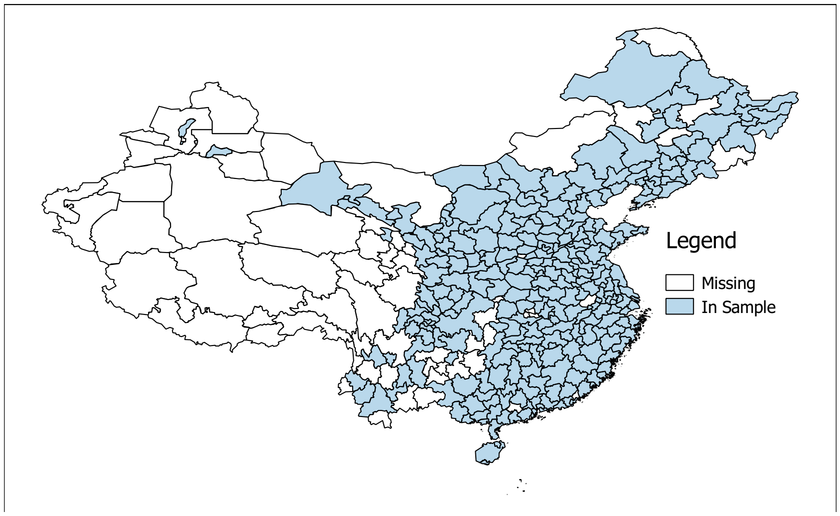


Figure 3.1: Prefecture-level Chinese Cities in Our Sample

Note: This graph plots the 279 prefecture-level cities in our sample. All the cities that are included in the *Chinese Statistical Yearbooks* and the *2005 One-Percent Population Survey* are in our sample.

revenue is less than the wage bill or the value of intermediate inputs, and the firms with non-positive value-added, total asset, fixed asset, or equity. We drop those with fewer than 20 employees and the foreign-owned firms as well. Our final sample contains on average 154.9 thousand firms per year. Table 1 presents some summary statistics in the sample of 2007. Around 96 percent of the sample was private firms. On average, the state-owned firms are 6.5 times larger in revenue, 5.0 times larger in employment, and 7.6 times larger in value-added than their private counterparts. The sharp differences in size are partially due to the SOE reforms in the late 1990s. While the government privatized most of the small SOEs during the reform, the largest SOEs in certain "pivotal industries" such as energy, telecommunication, and heavy industrial equipment remained state-owned.

3.2 Estimation of Output and Labor Frictions

We follow the approach in Hsieh and Klenow (2009) to estimate output and labor distortions — denoted as $\{\tau^d_{\ell,j}, \tau^d_{y,j}\}$ — in each city j and type d. The readers may refer to Hsieh and Klenow (2009) for the details of the procedure. We mainly focus on the estimation results here.

Solving firm k's cost minimization problem leads to the following estimate for the labor

Table 1: Summary Statistics, 2007

(a) State-Owned Firms

Variable	Mean	Std. Dev	Min.	Max.	N
Total Sales	718,829	4,458,436	356	180,000,000	10,750
Employment	1,063	4,763	21	134,614	10,750
Value Added	238,303	1,591,135	1	60,486,000	10,750

(b) Non-State Firms

Variable	Mean	Std. Dev	Min.	Max.	N
Total Sales	110,860	958,913	300	195,000,000	257,335
Employment	213	831	21	188,151	257,335
Value Added	31,500	382,618	1	163,000,000	257,335

Notes: The data come from the 2007 *China Annual Industry Surveys*. Total sales and value added are in thousands RMB, and employment is in the unit of person.

frictions, $\tau_{\ell,j}^{d}(k)$:

$$\tau_{\ell,j}^{d}(k) = \frac{\beta_{i(k)}}{1-\beta_{i(k)}} \cdot \frac{P_j Y_j^d(k)}{w_j L_j^d(k)} - 1,$$

where $i(k)$ is the industry to which firm k belongs and $\beta_{i(k)}$ is the corresponding labor intensity in that industry. $w_j L_j^d(k)$ is the total wage bill, and $P_j Y_j^d(k)$ is the firm's non-labor cost, which includes the expenditure on intermediate goods and the cost of capital. We compute the cost of capital as the depreciation cost of total asset plus the cost of financing, which in turn equals to the total assets times the risk-free interest rate.[5] All the variables can be directly observed in the data and thus the estimation is straightforward.

Similarly, the profit maximization problem leads to the estimation of output frictions:

$$\tau_{y,j}^{d}(k) = 1 - \frac{1}{1-\beta_{i(k)}} \frac{\varepsilon}{\varepsilon-1} \frac{P_j Y_j^d(k)}{R_j^d(k)},$$

where $R_j^d(k)$ denotes firm k's sales revenue, which is also available in the data.

The methodology outlined above requires estimations of labor intensity at the industry level, β_i. We allow labor intensity to vary across 491 industries at the 4-digit level, and use the *Annual Surveys* to estimate the labor intensities.[6] We define the labor share in each

[5]We use the average annual interest rates of China from World Development Indicators between 2000 and 2005, which is 5.58 percent.

[6]We drop the industries with fewer than 20 firms.

industry as the ratio of total wage bill to the total sales revenue.

Conditional on the estimated output and labor frictions at the firm level, we estimate the city-ownership frictions as the weighted average across firms:

$$\tau_{\ell,j}^{d} = \sum_{k} \tau_{\ell,j}^{d}(k)\,\omega_{jl}^{d}(k)\,,$$
$$\tau_{y,j}^{d} = \sum_{k} \tau_{y,j}^{d}(k)\,\omega_{jy}^{d}(k)\,,$$

where $\omega_{jl}^{d}(k)$ is the employment share of firm k in city j, type d, and $\omega_{jy}^{d}(k)$ is the sales revenue share.

We estimate the standard errors of $\tau_{\ell,j}^{d}$ and $\tau_{y,j}^{d}$ with 200-repetition bootstrapping. In each bootstrap, we draw the same number of firms within each city and repeat the above procedure for the entire sample.

3.3 Estimation Results

3.3.1 Frictions Over Time and Ownership

Figure 1.1 reports the aggregate results over time. Each panel reports the national average of labor and output frictions across all the cities from 1998 to 2007 by types of the firm. Several features stand out from the estimation.

Labor was heavily subsidized among the SOEs. The average labor friction ranges between -0.28 and -0.34 over the years, which means that the implicit labor subsidy is around 1/3 of the total payroll. In contrast, labor frictions among private firms were not significantly different from zero before 2004, and only dipped to -0.07, a subsidy that equals to about 7 percent of payroll in 2007. The relative advantage of SOEs in the labor market was large and statistically significant, potentially due to their advantage in securing work permit and household registrations for their employees. In addition, the subsidies might also reflect better job security and social welfare programs at the SOEs.

Output frictions stay positive for both types of firms throughout the years, indicating the existence of policies or organizational inefficiencies that restrict the size of the firms. The frictions among SOEs have steadily declined from 0.11, or an equivalent of 11 percent sales tax in 1998 to 5 percent in 2007. The 55 percent improvement is probably due to the new waves of SOE reforms in the late 1990s. Although the initial SOE reforms started in the 1970s, the profitability and solvency of these firms still slowly deteriorated over time, and the problem at SOEs worsened in the 1990s due to the ever-increasing competition from the private and foreign firms. In 1998 as many as 15 percent of the SOE firms reported loss, while the corresponding statistics for the private firms is only 3.5 percent as documented in the *Annual Surveys*. To resolve these issues, the central government initiated a new wave of reforms that involved large-scale lay-offs, debt-equity swaps, and buyouts or bankruptcies for small-scale and insolvent SOEs. The remaining large SOEs also reformed their corporate governance practices: most firms were incorporated into limited-liability companies or joint-venture companies. As a result, they redefined their identities as profit-maximizing business units instead of production and social units inside a centrally-planned economy. Following these reforms, the number of SOEs gradually decreased from 59,975 in 1998 to 14,744 in 2007, and their average profitability, measured as return to assets, increased from 0.04 to 0.14.[7] The improvements in efficiency are ultimately reflected as the 55-percent reduction in output frictions in our estimation.

In contrast, the output frictions among the private firms have steadily increased from 1.6 percent sales-tax-equivalent in 1998 to 3 percent in 2007. The 1.4 percentage points increase in the average output frictions suggests that the business environment has deteriorated for the private firms. Part of this deterioration might be the result of increasing foreign competition: our point estimate of the average frictions started to increase after 2002, the year in which China joined the World Trade Organization (WTO). The deterioration might also be the flip-side of the above-mentioned SOE reforms, which strengthened the market power of large SOEs in many upstream industries, such as energy, telecommunications, and transportation. The concentration of the market power might have lead to higher operating costs for the private firms. Nevertheless, even at 2007, the average output frictions among private firms were still about 40 percent lower than that of the SOEs: despite the reforms, the SOEs still have a long way to go to catch up with the private firms.

[7] Source: the authors calculations using the *Annual Surveys*

3.3.2 Frictions over Space

The frictions also differ across cities. In this section, we focus on the estimates in 2007 and examine the relationship between the distortions and city characteristics. Table 2 reports regressions of the city-specific frictions against the logarithm of GDP and population in each city. The upper panel uses the absolute values of the frictions on the left-hand-side, while the lower panel uses the frictions themselves. As shown in the upper panel, larger cities are less distorted in both frictions. On average, a 10-percent increase in city size lowers the absolute value of labor frictions among SOEs by around 0.007, or $0.007/0.401 \approx 1.8$ percent of national mean; similarly, a 10-percent increase in city size reduces the absolute values of labor frictions among private firms by around 0.0027 to 0.0053, which is around 1.1 to 2.2 percent of the national mean of 0.242. The output frictions among private firms are lower in larger cities as well. On average, a 10-percent increase in local GDP reduces output frictions among private firms by $0.0009/0.052 \approx 1.7$ percent, and in the case of population, $0.0017/0.052 \approx 3.3$ percent.[8] However, output frictions among SOEs do not seem to vary across cities.

As labor frictions in most cities are negative, the above results imply that labor is less subsidized, or the labor frictions are higher in larger cities. The lower panel of the same table confirms that this is indeed the case. Higher labor frictions in larger cities might reflect the policy differences in terms of the migration and labor law enforcement. In China, it is significantly harder to obtain work permits and Household Registration in larger cities, and this is likely to increase the de facto costs of hiring workers in these locations. Similarly, larger cities are usually better governed, which implies that labor laws on worker welfare and safety standards are likely to be enforced more strictly, another factor that might increase the costs of labor. In addition, larger cities might have better access to financial markets and the transportation networks, and thus the firms might be more capital- or intermediate-inputs-intensive than those in smaller cities.

Since output frictions in most cities are positive, the above estimates imply that output frictions are lower in larger cities. Intuitively, larger cities are likely to be endowed with better infrastructure and access to markets, which tend to improve productivity. Moreover,

[8] The average absolute values of the frictions across cities are reported in Table 7.

private firms in larger cities might have access to better managerial practices as well, which also tend to lower output frictions.

Table 2: Distortions v.s. City Characteristics

(a) Absolute Values of Frictions

	Abs(Labor, SOE)		Abs(Labor, Private)		Abs(Output, SOE)		Abs(Output, Private)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(GDP)	-0.069***		-0.027**		-0.005		-0.009***	
	(0.012)		(0.011)		(0.005)		(0.003)	
Ln(Pop.)		-0.072***		-0.053***		-0.005		-0.017***
		(0.014)		(0.015)		(0.006)		(0.006)
Constant	0.839***	0.761***	0.412***	0.510***	0.129***	0.122***	0.112***	0.137***
	(0.077)	(0.074)	(0.075)	(0.082)	(0.032)	(0.032)	(0.018)	(0.031)
N	279	279	279	279	279	279	279	279
R-squared	0.093	0.068	0.014	0.043	-0.000	-0.001	0.025	0.059

Robust standard errors reported in parentheses
* p<0.10, ** p<0.05, *** p<0.01

(b) Frictions

	Labor, SOE		Labor, Private		Output, SOE		Output, Private	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ln(GDP)	0.077***		0.066***		-0.003		-0.015***	
	(0.018)		(0.019)		(0.007)		(0.004)	
Ln(Pop.)		0.075***		0.043*		-0.003		-0.023***
		(0.021)		(0.026)		(0.009)		(0.007)
Constant	-0.840***	-0.720***	-0.491***	-0.287**	0.070	0.066	0.128***	0.145***
	(0.117)	(0.111)	(0.124)	(0.136)	(0.047)	(0.045)	(0.025)	(0.036)
N	279	279	279	279	279	279	279	279
R-squared	0.058	0.035	0.038	0.008	-0.003	-0.003	0.041	0.064

Robust standard errors reported in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Notes: the table reports regressions of city-level frictions against GDP and population.

Table 3 reports the (absolute values of) frictions across broader regions. The output frictions among SOEs are not significantly different across the regions, and the output frictions among the private firms are higher in the Middle and the Western regions as compared to the Eastern coast. Both types of the firms in the Western part of the country suffer from higher labor frictions as compare to the East. The cities in the Middle regions also suffer dis-advantages in labor frictions among SOEs, though to a lesser degree. The pattern across broader regions convey a similar message as the city-level regressions, since the cities in the Middle and the West are usually smaller than those along the Eastern coast.[9]

Table 3: Regional Differences in Frictions

(a) Absolute Values of Frictions

	Abs(Output Frictions)		Abs(Labor Frictions)	
	SOE	Private	SOE	Private
Northest	0.003	0.006	0.032	-0.034
	(0.018)	(0.010)	(0.042)	(0.038)
Middle	0.009	0.017**	0.052*	-0.003
	(0.013)	(0.007)	(0.029)	(0.027)
West	0.024	0.035***	0.114***	0.072**
	(0.014)	(0.008)	(0.034)	(0.031)
N	279	279	279	279
R-squared	-0.001	0.052	0.030	0.022

Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

(b) Frictions

	Output Frictions		Labor Frictions	
	SOE	Private	SOE	Private
Northest	0.006	0.036***	-0.093	-0.092
	(0.024)	(0.013)	(0.059)	(0.059)
Middle	0.022	0.055***	-0.061	-0.009
	(0.017)	(0.009)	(0.042)	(0.042)
West	0.051**	0.070***	-0.130***	-0.231***
	(0.020)	(0.010)	(0.048)	(0.048)
N	279	279	279	279
R-squared	0.015	0.165	0.017	0.084

Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

Notes: the table reports the regressions on city-ownership level frictions against regional dummies. See Table B.1 for the definition of the regions.

4 Calibration

The model is calibrated into the Chinese economy in 2007. We focus on the 279 prefecture-level cities discussed in the previous section (Figure 3.1). Given the estimated output and

[9] Table B.1 in Appendix B provides the definition of the regions.

labor frictions, our parameter space contains: $\{\varepsilon, \theta, \mu, \beta, \lambda, f_e\}$, the population distribution $\{L_j\}$, and two series of origin-destination specific matrices $\{f_{ij}, t_{ij}\}$. ε is the elasticity of substitution across varieties. We assign a value of 6.0 so it is consistent with the range commonly used in the literature. Firm size follows a power law distribution in our model that is captured by a tail index of $\theta/(\epsilon-1)$. We let θ be 5.3 so that the tail index equals 1.06, the value documented in Axtell (2001). β reflects the share of labor in total outputs, and we calibrate it using the China 2002 input-output table.[10] We use the basic flow table of 20 manufacturing industries and set $\beta = 0.30$ as the average ratio of total labor compensation to total output across all the industries. We directly obtain the population distribution $\{L_j\}$ from *City Statistical Yearbook* in 2007.

We jointly calibrate the remaining parameters. For the fixed operating costs matrix f_{ij}, we follow the strategy in Ma and Tang (2016) by approximating the fraction of entrepreneurs in each city among the working population in the *2005 One-Percent Population Survey*. We set the off-diagonal elements, f_{ij}, as the sum of the two diagonal elements f_{ii} and f_{jj}. Following Di Giovanni and Levchenko (2012), we scale the f_{ij} matrix by a factor ζ to ensure interior solutions in all the benchmark and counter-factual simulations.[11] We assume that the entry cost in the unit of input bundles, f_e, is the same across cities because differences in infrastructures and institutions across cities are unlikely to affect the costs of becoming an entrepreneur. As the costs of the input bundles generally differ across space in equilibrium, the monetary costs of entry vary across cities as well. We calibrate this parameter to match the number of firms in Shanghai, the largest city in China, which is around 340 thousands.[12] λ governs the probability of becoming state-owned firms upon entry. We obtain this value by matching a 21.2 percent of SOE among all registered firms according to the *Second Economic Census* in 2004.

We directly obtain the geographic trade cost matrix, T, from Ma and Tang (2016). The matrix describes the relative costs of transportation based on real-world road, railway, and

[10] We prefer the I/O tables to the *Annual Surveys* when computing β mainly because the I/O tables are based on a more representative sample of firms, while the *Annual Surveys* are biased toward the state-owned firms.

[11] The interior solution is $a_{ij} <= 1/\mu$, where μ is the lower bound of the productivity distribution. We calibrate ζ such that the number of entering firms is twice of the number of operating firms in the benchmark model. This is to guarantee that some entering firms choose not to operate.

[12] The data source is the Second Economic Census carried out in 2004.

river networks between all city pairs. We assume that the iceberg trade costs in our model are:

$$t_{ij} = \begin{cases} \bar{\tau} T_{ij}, & i \neq j \\ 1, & i = j \end{cases}.$$

We calibrate $\bar{\tau}$ to match the ratio of inter-city trade to GDP in China, which we estimate from *Investment Climate Survey 2005* published by the World Bank. This survey covers 12,500 firms in mainland China. Each firm was asked to report the percentage of sales by destination: within-city, within-province, across-provinces, or overseas. On average, 62.5 percent of the total revenue was generated outside of the local city, and thus we calibrate $\bar{\tau}$ to match the same trade/GDP ratio in our model. We summarize all the parameters and their corresponding targets in Table 4.

Table 4: Benchmark Parameterizations

Para.	Targets	Value
β	labor share	0.30
θ	Pareto index in emp. distribution	5.3
ϵ	elasticity of substitution	6.0
f_e	number of firms, Shanghai	0.71
λ	percent of registered SOEs	0.19
$\bar{\tau}$	internal trade/GDP ratio	2.19
ζ	entrants/operating firm ratio	0.03
$\{L_j\}$	population distribution	

Note: The calibration target for β comes from the 2002 Chinese input-output table for 20 industries. The target for θ comes from Axtell (2001), and the value for ϵ and the target for ζ come from Ma and Tang (2016). The target for f_e comes from the *2005 One-Percent Population Survey*. The target for $\bar{\tau}$ comes from the *Investment Climate Survey* published by the World Bank.

5 Quantitative Results

We evaluate the aggregate and distributional impacts of micro-frictions with counter-factual exercises. Our benchmark model is calibrated to the Chinese economy in 2007. We first eliminate all the frictions by setting them to zero, and decompose the overall impacts of the frictions along several dimensions: labor reallocation, firm entry, and spatial variations. We then study the impacts of frictions over time between 1998 and 2007. The results of these counter-factual simulations are summarized in Tables 5.

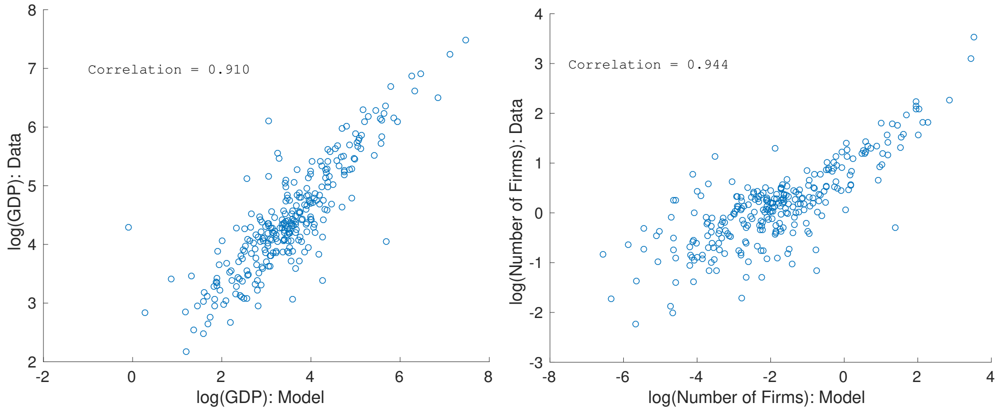
We focus on the welfare implications of the frictions. To make welfare across benchmark and counter-factual exercises comparable, we measure welfare by the real disposable income, which is the sum of labor income and the lump-sum transfer/taxation divided by the ideal price index:

$$\text{Welfare}_i = \text{Real Disposable Income}_i = \frac{w_i L_i + \sum_{d=S,N}\left(\tau_{l,i}^d w_i L_i^d + \tau_{y,i}^d X_i^d\right)}{P_i}.$$

For example, if the tax revenue collected due to the frictions in city i is positive, the local government is running a surplus, and thus will reimburse all the workers in the city with a lump-sum transfer. Conversely, if the government is handing out subsidies and thus running a deficit, they need to tax the local workers to balance the budget. As mentioned in Section 2, we measure the size of the distortions in city i by the ratio of the implied taxation revenue or deficit to local GDP:

$$\text{Size of Distortion}_i = \frac{\sum_{d=S,N}\left(\tau_{l,i}^d w_i L_i^d + \tau_{y,i}^d X_i^d\right)}{w_i L_i + \sum_{d=S,N}\left(\tau_{l,i}^d w_i L_i^d + \tau_{y,i}^d X_i^d\right)}.$$

Before we start the counter-factual analysis, we first describe the model-fit by comparing with some untargeted moments. The left panel of Figure 5.1 plots the GDP distribution from the data against the model counterparts. The model captures the overall distribution with a correlation of 0.91. The right panel of the same figure compares the number of registered firms taken from the *Second Economic Census (2004)* with the number of operating firms in our model. Again, the model has successfully mimicked the data pattern with a correlation of 0.94. The first column in Table 5 also reports that in our baseline simulation, SOEs take up around 31.0 percent of total employment share, close to what is observed in the data at around 34.8 percent (Fang et al., 2009).



(a) GDP Model Fit (b) Number of Firms Model Fit

Figure 5.1: Model Fit

Notes: In the left panel, we plot the log of city-level GDP taken from *China City Statistical Yearbook* on the y-axis against the log of total real income predicted by the model on the x-axis. In the right panel, we plot the log of number of firms taken from the Second Economic Census (2004) on the y-axis against log of number of operating firms predicted by the model on the x-axis.

5.1 Impacts of Frictions in 2007

All the distortions in 2007 lead to a government deficit equivalent to 20.1 percent of the aggregate nominal GDP (column 1, Table 5). Output frictions generated a slightly positive government revenue, at around 1.5 and 0.9 percent of nominal GDP for SOE and private firms, respectively. The local governments subsidize labor input heavily, which leads to deficits at around 11 percent of nominal GDP for each type of firms. Although at the aggregate level, the size of distortions are similar between the two types of firms, the distortions at the firm-level vary significantly. SOEs only constitute $52.4/262.3 \approx 20$ percent of the firms. This implies that the output frictions per SOE firm is $\frac{0.015}{0.009} \times \frac{1-0.2}{0.2} - 1 \approx 5.67$ times higher than that of private firms. Similarly, the labor subsidies that the SOE firms receive is $\frac{0.113}{0.111} \times \frac{1-0.2}{0.2} - 1 \approx 3.07$ times higher than that of the private firms. The bias hints why the frictions might lead to misallocation across the types of firms and be costly: the labor subsidies among SOEs are higher, which draw workers away from the private sectors; at the same time, the SOEs also have higher output frictions, and thus are less productive. The unfortunate correlations between labor and output frictions might impose a sizable cost on aggregate welfare.

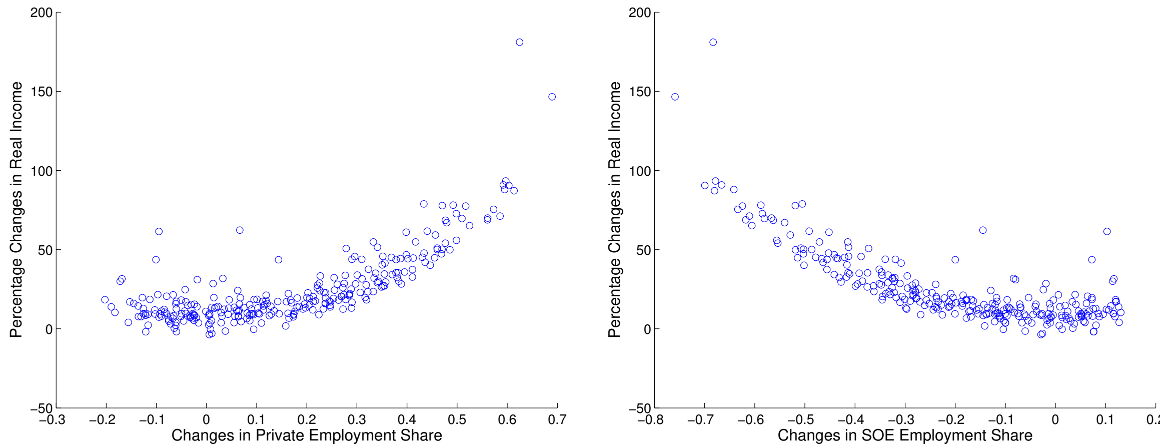
We quantify the impacts of the frictions by running a counter-factual exercise in which

Table 5: Aggregate Results

	Benchmark	Frictionless	No Ownership Diff.	No Entry	No Spatial Diff.	1998
Real Income	249.81	282.27	260.90	256.00	252.99	256.47
	Size of Distortions					
Aggregate	-0.201	0.000	-0.147	0.000	-0.049	-0.108
Output, SOE	0.015	0.000	0.011	0.000	0.034	0.020
Output, Private	0.009	0.000	0.055	0.000	0.062	-0.026
Labor, SOE	-0.113	0.000	-0.035	0.000	-0.101	-0.080
Labor, Private	-0.111	0.000	-0.178	0.000	-0.043	-0.022
	Employment Share					
SOE	0.310	0.163	0.163	0.150	0.301	0.260
Private	0.689	0.836	0.837	0.747	0.699	0.740
	Number of Operating Firms					
Total	262.30	273.51	255.46	262.30	240.07	265.11
SOE	52.41	44.62	41.68	52.41	65.95	58.18
Private	209.88	228.89	213.78	209.88	174.12	206.94
	Inequality Measures					
Most Improved City(%)	-	181.066	133.244	77.611	151.903	144.483
Least Improved City(%)	-	-3.670	-16.104	-9.085	-13.664	-55.226
Coef. of variation	2.546	2.384	2.359	2.448	2.384	2.480
SD(LN(Real Income))	1.221	1.155	1.178	1.203	1.155	1.206
Trade Openness	0.625	0.617	0.620	0.621	0.617	0.624

Note: This table reports the aggregate impacts of our four counter-factual analyses. Column 2 eliminates all the frictions. Column 3 assumes that the frictions are equalized to the mean value between the two types of firms within each city. Column 4 shuts down the channel of firm entry and exit. Column 5 equalizes each type of frictions across all the cities to their respective mean. Column 6 reverts the frictions to their levels in 1998. We report levels in real income, size of distortions, employment share, number of operating firms, trade openness and certain income inequality measures.

all the frictions are set to zero. The second column in Table 5 reports the results. Removing all the frictions leads to a $282.27/249.81 - 1 \approx 13$ percent gain of real disposable income at the aggregate level. The frictions in 2007 favor the SOEs: once the frictions are removed, the employment share of the SOEs dropped from 31.0 percent to 16.3 percent and the number of operating SOEs dropped by $1 - 44.62/52.41 \approx 14.9$ percent. On the other side, the private firms benefit in the frictionless economy: their employment share increased to 83.6 percent, and the number of operating firms increased by $228.89/209.88 - 1 \approx 9.06$ percent. At the local level, the cities with higher real income growth are those with higher growth in private employment share as well, as seen in Figure 5.2. Removing the frictions in 2007 also lowers the coefficient of variation across city-level real income by around $1 - 2.384/2.546 \approx 6.36$ percent, and the standard deviation of the logarithm of real income by around $1 - 1.155/1.221 \approx 5.41$ percent. Removing all the frictions also slightly lowers the



(a) Private

(b) SOE

Figure 5.2: Employment Share and Gains in Real Income

Notes: This figure plots the percentage changes in real disposable income against the percentage changes in employment share from the benchmark to the frictionless case. Each dot represents a city.

inter-city trade share from 0.625 to 0.617.

The frictions could potentially affect the aggregate welfare and spatial inequality through several channels. The first source is the misallocation of workers between the two types of firms as discussed above. The second source is the potential impact on firm entry and exit. Output frictions directly restrict the size of the firms, which in turn distort the potential entrepreneur's decision to enter in the first place. As our model allows for the "love of variety" effects, the extensive margin of entry and exit might have a large impact on welfare through the price index. Lastly, the spatial variations of the distortions might affect the aggregate welfare as well, as they distort the entry and production decisions across cities through inter-city trade. In the rest of the section, we proceed to look into the different dimensions in detail by using various counter-factual analysis.

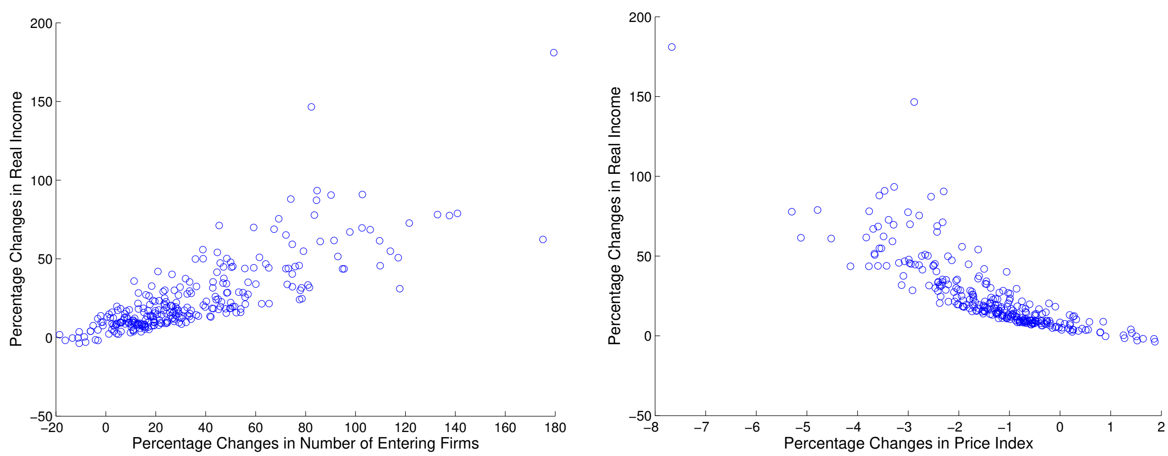
Labor Re-allocation

To single out the effects of labor re-allocation across sectors, we conduct a set of counter-factual analysis in which we only eliminate the sectoral differences of the frictions within each city, while maintaining the mean level of frictions. Instead of setting all the frictions to zero, we equalize the frictions between both types of firms to the simple averages within the city. The results of this counter-factual are reported in column 3 of Table 5 under column

"No Ownership Diff". As workers cannot move across cities, removing within-city difference is enough to ensure that workers are allocated exactly the same as in the frictionless case, as can be seen by comparing the employment share between this and the "Frictionless" column in Table 5. Removing the ownership difference leads to a 4.44 percent increase in real income, which is around $4.44/13.0 \approx 34.2$ percent of welfare gains in the frictionless case. Though the magnitude of labor reallocation is large, the explanatory power of labor-reallocation is relatively low. This is probably due to the fact that by 2007, the differences in output frictions between SOEs and private firms were already small.

Firm Entry/Exit

The number of operating firms increased by 4.28 percent between the frictionless and the baseline simulations, which might also affect aggregate welfare through the ideal price index, or the "love of varieties" effect commonly found with CES utility functions. At the city level, the impacts of the extensive margin can also be observed: the cities that benefited more in the frictionless economy tend to be those that experienced higher growth rates in firm entry and lower price index, as seen in Figure 5.3.



(a) Number of Entering Firms

(b) Ideal Price Index

Figure 5.3: Extensive Margin and Real Income

Notes: This figure plots the percentage changes in real disposable income against the percentage changes in the number of operating firms and the ideal price index between the benchmark and the frictionless case. Each dot represents a city.

To evaluate the effects of the extensive margin, we carry out another set of counter-factual analysis, in which we fix the number of operating firms in each city-ownership cell to their values in the baseline model, and then remove all the frictions. The results are reported in the columns "No Entry" in Table 5. Comparing to the baseline results, the aggregate real income only improves by around $256/249.81 - 1 \approx 2.48$ percent when the number of firms is fixed, implying that $1 - 2.48/13.0 \approx 80.9$ percent of the gain in real income can be attributed to the changes in the extensive margin. The high explanatory power of the extensive margin is not a surprising result: Yang (2016) also found that endogenous firm entry and exit can have significant impacts on how misallocation affect TFP through firm selections with the "love of variety" effects purposefully shut down. In our analysis, the power of the extensive margin is further amplified by the the variety effects introduced by new firm entry.

Implications on Spatial Inequality

Table 5 reports that removing the frictions lower spatial inequality by around 5 percent. This is probably due to the fact that larger cities are less distorted than smaller ones (see Table 2), and thus are expected to benefit less from the removal of the frictions. Figure 5.4 shows that it is indeed the case in the simulation: a 10 percent increase in city size is associated with 0.6 percentage point lower gain in real GDP between the baseline and the frictionless counter-factual.

To further study the impacts of the spatial misallocation, we simulate without the spatial differences while retaining the differences across sectors by setting the frictions in all city-type cells to their national average. The results of this simulation are reported in column "No Spatial Differences" in Table 5. Comparing to this simulation, the benchmark simulation is a mean-preserving spread of the frictions and the frictionless simulation is a parallel shift of the mean from the national average to zero. Comparing across the three cases allows us to single out the impacts of spatial dispersion of the frictions.

Without the spatial dispersion of the frictions, the aggregate real income increases by around $252.99/249.81 \approx 1.27$ percent, which is about $1.27/13 \approx 9.8$ percent of the overall welfare gain towards the frictionless case. The gain in aggregate welfare is mainly channeled through inter-city trade: larger cities have advantages in output frictions as compared to the smaller ones, which suppresses firm entry in the smaller cities in trade equilibrium. Removing

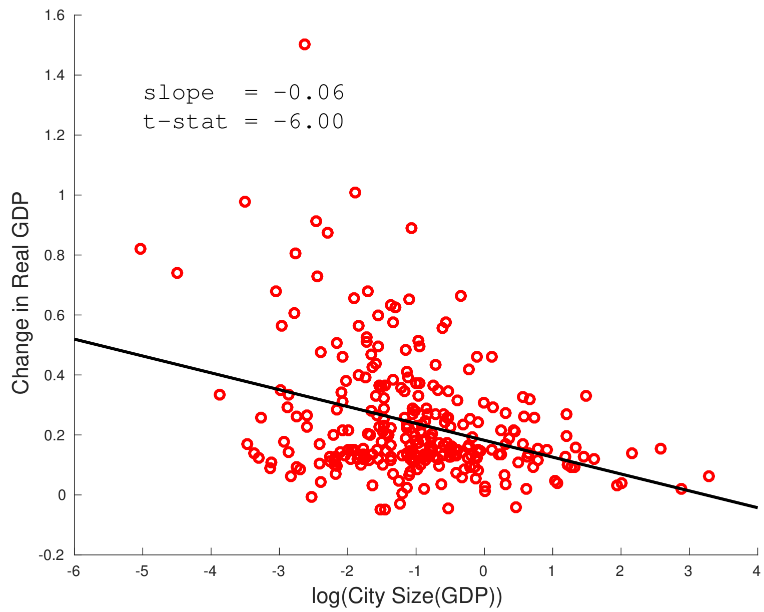


Figure 5.4: City size v.s. Changes in Real GDP, Frictionless

Notes: We measure city size by log of GDP at the x-axis. On the y-axis, we plot changes in real GDP at the city level between the friction-less economy and the benchmark model.

the advantages in the large cities allows more firms in the smaller cities to survive, and thus the gain in aggregate welfare. A flip-side of the effects is the lowered trade openness reported in the last row in Table 5: without the disadvantages in output frictions, the consumers in small cities will source more from local firms instead of relying on the products of the large cities via inter-city trade.

Removing the spatial differences in frictions also lowers the spatial inequality to exactly the same level as in the frictionless case. In fact, the real income in each city is proportional between the frictionless and the "no-spatial difference" case, suggesting that all the spatial inequality caused by the frictions is rooted in the spatial differences of the frictions, not the average levels of the frictions themselves. In other words, proportionally lowering the frictions will lead to the same impact on real income, regardless of city characteristics, such as population size and its relative position in the trade networks.

Between our baseline and the frictionless case, the cities that gained the most see its real income increased by as much as 181 percent. On the other hand, not all the cities benefit from the removal of frictions: 7 cities suffered *loss* in real income once the frictions are removed, and the largest loss is about 3 percent. The losing cities tend to have large subsidies in output, which support a higher number of firms in our baseline economy. Once the output subsidies are removed, the number of varieties decreased dramatically so that the real income drops. This implies that at the local level, a frictionless economy might not be the first-best equilibrium.

5.2 Decomposition of Frictions in 2007

The upper panel in Table 6 studies the impacts of shutting down individual types of frictions. Shutting down labor frictions among SOEs in all the cities leads to the highest gain in aggregate welfare: $264.59/249.81 - 1 \approx 5.92$ percent, or $5.92/13 \approx 45.5$ percent of the aggregate gain in the frictionless case. The mechanism behind the gain is similar to what we have documented before: without the favorable treatment to labor in SOEs, workers are reallocated to the more productive private sectors, leading to more firm entry into the private sectors and thus larger aggregate gain. Removing the output frictions from the private sectors leads to a similar but smaller scale of labor re-allocation, and thus less gains in aggregate welfare: $257.52/249.81 - 1 \approx 3.09$ percent, or $3.09/13 \approx 23.7$ percent of the overall gain from the frictionless economy.

In contrast, removing labor frictions from the private sector or the output frictions from the SOE sector will slightly lower the aggregate welfare by around 1 percent. Both actions slightly increase the number of operating SOE firms at the cost of private firms. Removing the labor subsidies from private firms effectively widens the gap in the costs of hiring between private and public firms, driving workers away from the private sector and lowering the aggregate output. Removing output frictions from SOEs directly improves their productivity and thus draw workers away from the private sectors. Since SOE sector also enjoys higher labor subsidies, higher employment share at the SOEs increases the size of the aggregate distortions to 25 percent of GDP from 20 percent in the baseline. The expansions of the SOEs lead to less firm entry into the private sector, and the resulting negative impacts exceed the gains in the SOE sectors, and eventually lead to lower aggregate welfare.

From the perspective of spatial inequality, removing the labor frictions from SOEs also leads to the highest reduction in inequality: the coefficient of variation declines from 2.546 to 2.404—a 5.57 percent decrease—almost on par with the effects from the removal of all the frictions. This is probably because the SOE sectors in the poorest cities of the inland provinces suffer significantly higher labor frictions, as documented in Section 3.

The lower panel of Table 6 shuts down the frictions by groups. Similar to the results reported above, shutting down labor frictions among both the SOE and the private firms leads to the highest gain in aggregate welfare: $270.21/249.81 - 1 \approx 8.17$ percent, or $8.17/13 \approx 62.8$ percent of the overall gain from the frictionless economy; the removal of the output frictions lead to $255.16/249.81 - 1 \approx 2.14$ percent, or $2.14/13 \approx 16.5$ percent of the overall gain. The dominant role of labor frictions is not surprising: the size of the labor frictions is roughly 10 times higher than that of the output frictions in the benchmark model. The changes in the employment share also indicate that the misallocation of workers across sectors is mainly caused by the labor, but not the output frictions.

Similarly, removing the frictions from SOEs leads to higher welfare gain than that among the private firms. This is again, mainly due to the labor-reallocation effects: removing SOE frictions releases workers to the private sectors, whereas removing private frictions will achieve the opposite.

5.3 Changing Frictions between 1998 and 2007

Lastly we simulate the model using the frictions estimated in year 1998, while keeping all the other parameters the same as in the benchmark model to study how the evolution of frictions have affected the Chinese economy. The summary statistics of the frictions estimated in the two years are reported in Table 7. Over the nine-year span, output frictions improved from 0.106 to 0.049, and the labor frictions further dipped from -0.281 to -0.346 among the SOEs. Over the same period, output frictions among private firms increased to 0.031, still lower than the SOEs, while the labor frictions decreased from 0.019 to -0.07. At a first glance the effects of the changing frictions are not immediately clear. Comparative statics between the two years reveal the general equilibrium impacts of the changing frictions.

The last column of Table 5 reports the aggregate results with the frictions estimated in 1998. The changes in frictions over the years had led to a $1 - 249.81/256.47 \approx 2.60$ percent *loss* in aggregate welfare. The loss of welfare is probably because the magnitude of distortions, measured as the implied deficit-to-GDP ratio, has almost doubled from 10.8

Table 6: Decomposition of Frictions

	Benchmark	SOE Output	Private Output	SOE Labor	Private Labor
Real Income	249.81	247.54	257.52	264.59	247.05
			Size of Distortions		
Aggregate	-0.201	-0.255	-0.208	-0.093	-0.106
Output, SOE	0.015	0.000	0.014	0.004	0.016
Output, Private	0.009	0.006	0.000	0.017	0.008
Labor, SOE	-0.113	-0.150	-0.110	0.000	-0.130
Labor, Private	-0.111	-0.110	-0.112	-0.115	0.000
			Employment Share		
SOE	0.310	0.366	0.287	0.141	0.353
Private	0.689	0.633	0.712	0.859	0.647
			Number of Operating Firms		
Total	262.30	265.10	261.49	267.97	258.31
SOE	52.41	65.25	52.32	30.02	63.29
Private	209.88	199.85	209.17	237.95	195.02
			Inequality Measures		
Most Improved City(%)	-	19.613	163.870	89.234	49.584
Least Improved City(%)	-	-32.136	-13.241	-11.645	-39.987
Coef. of variation	2.546	2.600	2.499	2.404	2.530
SD(LN(Real Income))	1.221	1.232	1.190	1.190	1.250
Trade Openness	0.625	0.626	0.620	0.621	0.628

	Benchmark	Output Friction	Labor Friction	SOE	Private
Real Income	249.81	255.16	270.21	269.18	254.83
			Size of Distortions		
Aggregate	-0.201	-0.257	0.020	-0.099	-0.112
Output, SOE	0.015	0.000	0.003	0.000	0.015
Output, Private	0.009	0.000	0.017	0.015	0.000
Labor, SOE	-0.113	-0.146	0.000	0.000	-0.127
Labor, Private	-0.111	-0.111	0.000	-0.115	0.000
			Employment Share		
SOE	0.310	0.341	0.156	0.168	0.330
Private	0.689	0.659	0.843	0.832	0.670
			Number of Operating Firms		
Total	262.30	263.81	269.72	272.06	257.47
SOE	52.41	65.25	36.77	37.12	63.35
Private	209.88	198.56	232.95	234.94	194.11
			Inequality Measures		
Most Improved City(%)	-	165.583	126.274	89.115	149.877
Least Improved City(%)	-	-38.774	-3.468	-3.243	-34.739
Coef. of variation	2.546	2.549	2.398	2.436	2.481
SD(LN(Real Income))	1.221	1.198	1.184	1.185	1.209
Trade Openness	0.625	0.621	0.621	0.621	0.622

Note: the two tables report counter-factual analysis similarly to those reported in Table 5. The upper panel removes labor or output frictions for each type of firms separately, and the lower panel removes the frictions by groups.

Table 7: Frictions in 1998 and 2007

(a) Frictions in 1998

Variable	Mean	Mean(Abs.)	Std. Dev.	Min.	Max.	N
SOE Output Friction	0.106	0.129	0.14	-0.168	0.632	279
Private Output Friction	0.016	0.061	0.089	-0.139	0.454	279
SOE Labor Friction	-0.281	0.339	0.259	-0.819	1.109	279
Private Labor Friction	0.019	0.290	0.405	-0.813	3.027	279

(b) Frictions in 2007

Variable	Mean	Mean(Abs.)	Std. Dev.	Min.	Max.	N
SOE Output Friction	0.049	0.095	0.118	-0.169	0.445	279
Private Output Friction	0.031	0.052	0.066	-0.101	0.492	279
SOE Labor Friction	-0.346	0.401	0.288	-0.805	1.418	279
Private Labor Friction	-0.07	0.242	0.299	-0.638	1.378	279

Notes: The mean values of the frictions come from the benchmark estimation, while the standard errors come from over 200 bootstrap. The data source is *Annual Surveys.*

percent to 20.1 percent. The changes in distortions are mainly driven by the expansion of payroll subsidies, which increased from 10.2 percent of the GDP in 1998 to 22.4 percent in 2007. At the same time, the output frictions slightly reverted from a 0.6 percent of subsidy to a 2.4 percent of taxation. Higher frictions in both dimensions will lead to higher distortions in prices and entry/exit decisions, imposing costs to aggregate welfare.

The share of SOEs in the number of operating firms slightly *decreased* from 21.95 percent in 1998 to 20 percent in 2007, and SOE employment share *increased* from 26 percent to 31 percent. Fewer SOEs combined with higher employment share imply that the average firm size among SOEs has increased by around 32 percent over the years. This finding is consistent with the designated SOE reform policy "grasp the large and let go of the small".

The changes in frictions also seem to increase the spatial inequality slightly. The coefficient of variation increased by 2.66 percent, from 2.48 to 2.546, and the standard deviation of the logarithm of real income increased by 1.24 percent, from 1.206 to 1.221.

6 Conclusion

In this paper, we propose a general equilibrium framework to evaluate both the aggregate and distributional impacts of micro-economic frictions. We empirically estimate a labor input friction that affects the firm's cost-minimization problem, and an output friction that restricts the size of the firm, from firm-level data, and then aggregate up to city-ownership level. We then calibrate the model to the Chinese economy in 2007 to study the impacts of these frictions.

The existing frictions divert workers toward the less productive SOEs, throttle firm entry in the private sectors, and overall lead to a 13-percent aggregate welfare loss in China. The frictions differ significantly across cities. Removing the spatial disparity of the frictions leads to slightly higher total output and lower spatial inequality in real income at the same time.

In future works we intend to extend our framework to include other elements into the evaluation of the welfare impacts of micro-economic frictions. Labor mobility within the country can be introduced following the methods introduced in Ma and Tang (2016); agriculture and rural workers can also be incorporated into the framework to study resource misallocation in the Chinese economy.

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Appendix

A Solving the Model

A.1 Autarky Equilibrium

In the autarky scenario, each individual firm only gets to serve its own home market. The expected profit at the entry stage can be expressed as:

$$
\begin{aligned}
& E\left[\pi\left(a\right)|a < a_j^d, d \in \{S, N\}\right] \\
= \; & \lambda E\left[\pi\left(a\right)|a < a_j^S\right] + \left(1-\lambda\right) E\left[\pi\left(a\right)|a < a_j^N\right].
\end{aligned}
$$

where a_j^d is the input bundle requirement below which firm of type d will get to serve the home market. The probability of drawing $a < a_j^d$ is $G\left(a_j^d\right)$ and the probability of being state-owned is λ. Thus, free entry condition in city j can be expressed as:

$$
\lambda G\left(a_j^S\right) E\left[\pi\left(a\right)|a < a_j^S\right] + \left(1-\lambda\right) G\left(a_j^N\right) E\left[\pi\left(a\right)|a < a_j^N\right] = f_e \bar{c}_j.
$$

We can then solve the price index P_j from the equation above:

$$
P_j = \left\{ \frac{1}{f_e} \frac{\varepsilon - 1}{\theta - \varepsilon + 1} \upsilon^{\theta} \left(\frac{\varepsilon-1}{\varepsilon}\right)^{\theta} X_j^{\frac{\theta}{\varepsilon-1}} f_j^{\frac{\varepsilon-1-\theta}{\varepsilon-1}} \varepsilon^{\frac{\theta}{1-\varepsilon}} w_j^{\beta\frac{\varepsilon\theta}{1-\varepsilon}} \Phi_1 \right\}^{\frac{\varepsilon-1}{(1-\beta)\varepsilon\theta - \theta(\varepsilon-1)}},
$$

where

$$
\begin{aligned}
\Phi_1 \; = \; & \left[\frac{1}{1-\beta}\left(\frac{1-\beta}{\beta}\right)\right]^{\frac{\epsilon\theta}{1-\epsilon}} \left[\lambda\left(1-\tau_{y,j}^S\right)^{\frac{\varepsilon\theta}{\varepsilon-1}} \left(1+\tau_{\ell,j}^S\right)^{\beta\frac{\varepsilon-1-\varepsilon\theta}{\varepsilon-1}} \right. \\
+ \; & \left. \left(1-\lambda\right)\left(1-\tau_{y,j}^N\right)^{\frac{\varepsilon\theta}{\varepsilon-1}\frac{\varepsilon\theta}{\varepsilon-1}} \left(1+\tau_{\ell,j}^N\right)^{\beta\frac{\varepsilon-1-\varepsilon\theta}{\varepsilon-1}} \right].
\end{aligned}
$$

Alternatively, price index can be expressed into:

$$P_j^{1-\varepsilon} = \sum_{d=S,N} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{c_j^d}{1 - \tau_{y,j}^d} \right)^{1-\varepsilon} I_j^d \cdot \text{Prob}(a_j(k) \leq a_j^d) \cdot E\left[a_j(k)^{1-\varepsilon} | a_j(k) < a_j^d \right].$$

Equalizing the above two expressions for price index above gives the number of entry firms M_j:

$$M_j = \sum_{d=S,N} I_j^d = (\frac{\varepsilon}{\varepsilon - 1})^{\theta} \left(\frac{1}{\upsilon} \right)^{\theta} \left(\frac{\theta}{\theta - \varepsilon + 1} \right)^{-1} \left(\frac{X_j}{\varepsilon} \right)^{\frac{\theta - \varepsilon + 1}{-(\varepsilon - 1)}} f_j^{\frac{\theta - \varepsilon + 1}{(\varepsilon - 1)}} w_j^{\beta \frac{\varepsilon\theta - \varepsilon + 1}{\varepsilon - 1}} P_j^{(1-\beta)\frac{\varepsilon\theta - \varepsilon + 1}{\varepsilon - 1} - \theta} \Phi_2.$$

where

$$\begin{aligned} \Phi_2 &= \left[\frac{1}{1-\beta} (\frac{1-\beta}{\beta}) \right]^{\frac{\epsilon\theta - \epsilon + 1}{\epsilon - 1}} \left[\lambda \left(1 - \tau_{y,j}^S \right)^{\frac{\varepsilon\theta - \varepsilon + 1}{\varepsilon - 1}} \left(1 + \tau_{\ell,j}^S \right)^{\beta \frac{\varepsilon\theta - \varepsilon + 1}{1 - \varepsilon}} \right. \\ &+ \left. (1 - \lambda) \left(1 - \tau_{y,j}^N \right)^{\frac{\varepsilon\theta - \varepsilon + 1}{\varepsilon - 1}} \left(1 + \tau_{\ell,j}^N \right)^{\beta \frac{\varepsilon\theta - \varepsilon + 1}{1 - \varepsilon}} \right]^{-1}. \end{aligned}$$

Total sales revenue from type d firms in city j can be expressed as:

$$X_j^d = \frac{\left(1 - \tau_{y,i}^d \right) X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{c_i^t}{1 - \tau_{y,i}^d} \right)^{1-\varepsilon} I_i^d \frac{\theta \upsilon^{\theta}}{\theta - \varepsilon + 1} \left(a_j^d \right)^{\theta - \varepsilon + 1}$$

Substituting the equation above into the following goods market clearing condition can lead to the solution of X_j and Y_j

$$X_j = Y_j + (1 - \beta) \left((1 - \tau_{y,j}^S) X_j^S + (1 - \tau_{y,j}^N) X_j^N \right). \tag{2}$$

where Y_j is the disposable income after the lump-sum transfer or taxation:

$$Y_j = w_j L_j + \sum_{d=s,n} \tau_{l,j}^d w_j L_j^d + \sum_{d=s,n} \tau_{y,j}^d X_j^d, \tag{3}$$

Finally, the labor demand by each type of firm in city j is:

$$L_j^d = \left(\frac{(1 + \tau_{\ell,j}) w_j}{P_j} \frac{1 - \beta}{\beta} \right)^{\beta - 1} I_j^d \left[\Omega \frac{X_j}{P_j^{1-\epsilon}} (a_j^*)^{1-\epsilon+\theta} + f_j \mu^{\theta} (a_j^*)^{\theta} \right], d = S, N. \tag{4}$$

The labor market clearing condition in each city is thus:

$$L_j^S + L_j^N + (I_j^S + I_j^N) \times f_e \times \left(\frac{P_j}{w_j}\right)^{1-\beta} \cdot \left(\frac{\beta}{1-\beta}\right)^{1-\beta} = L_j, \tag{5}$$

where $\Omega = (\frac{\epsilon}{\epsilon-1}\frac{c_j^d}{1-\tau_{y,j}^d})^{-\epsilon}\mu^\theta \frac{\theta}{1-\epsilon+\theta}$.

A.2 Trade Equilibrium

In each city, we need to solve $\{w_j, M_j, P_j\}$. When we assume that $\frac{1}{a}$ follows a type-1 Pareto distribution, $\Pr\left(\frac{1}{a} < y\right) = 1 - (\mu y)^\theta$, together with the expression for the price index for composite variety:

$$P_i^{1-\varepsilon} = \sum_{j=1}^{J} \sum_{d=S,N} \left(\frac{\varepsilon}{\varepsilon-1}\frac{t_{ij}c_j^d}{1-\tau_{y,j}^d}\right)^{1-\varepsilon} I_j^d Pr(a_{ij}(k) \le a_{ij}^d) E\left(a_{ij}(k)^{1-\varepsilon} | a_{ij}(k) < a_{ij}^d\right),$$

and a_{ij}^S and a_{ij}^N from zero profit conditions

$$a_{ij}^d = \frac{\varepsilon-1}{\varepsilon}\frac{\left(1-\tau_{y,j}^d\right)P_i}{t_{ij}c_j^d}\left(\frac{\left(1-\tau_{y,j}^d\right)X_i}{\varepsilon c_j^d f_{ij}}\right)^{\frac{1}{\varepsilon-1}}, d = S, N,$$

we can rewrite the expression for the price index in city i as

$$P_i = \frac{\varepsilon}{\varepsilon-1}\frac{1}{\upsilon}\left(\frac{\theta}{\theta-\varepsilon+1}\right)^{\frac{-1}{\theta}}\left(\frac{X_i}{\varepsilon}\right)^{\frac{\theta-\varepsilon+1}{-\theta(\varepsilon-1)}}\left[\sum_{j=1}^{J}\sum_{d=S,N}\left(\frac{t_{ij}c_j^d}{1-\tau_{y,j}^d}\right)^{-\theta} I_j^d \left(\frac{c_j^d f_{ij}}{1-\tau_{y,j}^d}\right)^{\frac{\theta-\varepsilon+1}{1-\varepsilon}}\right]^{\frac{-1}{\theta}}.$$

The free entry condition in city j gives

$$\sum_{i=1}^{J}\left\{\begin{array}{c}\lambda\left[\frac{\left(1-\tau_{y,j}^S\right)X_i}{\varepsilon P_i^{1-\varepsilon}}\left(\frac{\varepsilon}{\varepsilon-1}\frac{t_{ij}c_j^S}{1-\tau_{y,j}^S}\right)^{1-\varepsilon}\frac{\theta\upsilon^\theta}{\theta-\varepsilon+1}\left(a_{ij}^S\right)^{\theta-\varepsilon+1} - G\left(a_{ij}^S\right)c_j^S f_{ij}\right] \\ +(1-\lambda)\left[\frac{\left(1-\tau_{y,j}^N\right)X_i}{\varepsilon P_i^{1-\varepsilon}}\left(\frac{\varepsilon}{\varepsilon-1}\frac{t_{ij}c_j^N}{1-\tau_{y,j}^N}\right)^{1-\varepsilon}\frac{\theta\upsilon^\theta}{\theta-\varepsilon+1}\left(a_{ij}^N\right)^{\theta-\varepsilon+1} - G\left(a_{ij}^N\right)c_j^N f_{ij}\right]\end{array}\right\} = f_e\bar{c}_j.$$

Moreover, the goods market clearing condition gives

$$X_j = Y_j + (1-\beta)\left((1-\tau_{y,j}^S)X_j^S + (1-\tau_{y,j}^N)X_j^N\right),$$

where Y_j is the disposable income after the lump-sum transfer or taxation:

$$Y_j = w_j L_j + \sum_{d=s,n}\sum_{i=1}^{J} \tau_{l,j}^d w_j L_{ij}^d + \sum_{d=s,n}\sum_{i=1}^{J} \tau_{y,j}^d X_{ij}^d,$$

and $X_j = X_j^S + X_j^N$.

Finally, the balance of trade condition requires that $X_i = \sum_{j=1}^{J} X_{ji}$, so in each country i, we have

$$X_i = \sum_{j=1}^{J} \Phi_3 X_j,$$

where

$$\begin{aligned}
\Phi_3 &= \frac{\sum_{d=S,N} I_i^d \left(t_{ji}\right)^{-\theta} \left(f_{ji}\right)^{\frac{\theta-\varepsilon+1}{1-\varepsilon}} \left(1-\tau_{y,i}^d\right)^{-\rho} w_i^{\beta\rho} \left(1+\tau_{\ell,i}^d\right)^{\beta\rho} P_i^{(1-\beta)\rho}}{\sum_{m=1}^{J} \sum_{d=S,N} \left(\tau_{jm}\right)^{-\theta} I_m^d \left(f_{jm}\right)^{\frac{\theta-\varepsilon+1}{1-\varepsilon}} \left(1-\tau_{y,m}^d\right)^{-\rho} w_m^{\beta\rho} \left(1+\tau_{\ell,m}^d\right)^{\beta\rho} P_m^{(1-\beta)\rho}}, \\
\rho &= \frac{\theta\varepsilon - \varepsilon + 1}{1-\varepsilon}.
\end{aligned}$$

Therefore, we have $2 * J + (J-1)$ equations to solve for w_j, M_j, P_j , where we normalize one city's wage rate to be 1.

A.2.1 Labor Demand

The labor demand in trade equilibrium can be computed as this. The total sales from city i to city j by types of firm s is:

$$\begin{aligned}
X_{ji}^s &= I_i^s \int_{1/a_{ji}^s}^{\infty} \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon-1}\frac{a\cdot t_{ji}c_i^s}{1-\tau_{y,i}^s}\right)^{1-\epsilon} d(G(1/a)) \\
&= I_i^s \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon-1}\frac{t_{ji}c_i^s}{1-\tau_{y,i}^s}\right)^{1-\epsilon} \frac{\mu^\theta\theta}{\theta-(\epsilon-1)} \left(a_{ji}^s\right)^{\theta-(\epsilon-1)}.
\end{aligned}$$

The number of input bundles required to generate these sales is:

$$
\begin{aligned}
d(c^s_{ji}) &= I^s_i \int_{1/a^s_{ji}}^{\infty} \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{a \cdot t_{ji} c^s_i}{1 - \tau^s_{y,i}} \right)^{-\epsilon} \cdot a \cdot d(G(1/a)) \\
&= I^s_i \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{t_{ji} c^s_i}{1 - \tau^s_{y,i}} \right)^{-\epsilon} \frac{\mu^\theta \theta}{\theta - (\epsilon - 1)} \left(a^s_{ji}\right)^{\theta - (\epsilon - 1)} .
\end{aligned}
$$

For each unit of input bundle, the labor demand that minimizes the costs is:

$$
\begin{aligned}
l^s_i &= \left[\frac{P_i}{(1 + \tau^s_{l,i}) w_i} \right]^{1-\beta} \left(\frac{\beta}{1 - \beta} \right)^{1-\beta} \\
&= \frac{\beta c^s_i}{(1 + \tau^s_{l,i}) w_i}
\end{aligned}
$$

and thus the labor demand behind the trade flow X_{ji} is:

$$
l^s_i \cdot d(c^s_{ji}) = \frac{\beta c^s_i}{(1 + \tau^s_{l,i}) w_i} \cdot \left\{ I^s_i \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{t_{ji} c^s_i}{1 - \tau^s_{y,i}} \right)^{-\epsilon} \frac{\mu^\theta \theta}{\theta - (\epsilon - 1)} \left(a^s_{ji}\right)^{\theta - (\epsilon - 1)} \right\} .
$$

Firms also need to purchase input bundles to cover the fixed costs of entry. The total demand for input bundles to cover fixed cost for all trade from i to j is:

$$
\begin{aligned}
d_{f,ji} &= f_{ji} I^s_i \int_{\frac{1}{a^s_{ji}}}^{\infty} d(G(1/a)) = f_{ji} I^s_i \cdot (1 - G(\frac{1}{a^s_{ji}})) \\
&= f_{ji} I^s_i \mu^\theta \left(a^s_{ji}\right)^\theta
\end{aligned}
$$

In the end the total labor demand to serve market j is:

$$
\begin{aligned}
L^s_{ji} &= l^s_i \cdot (d(c^s_{ji}) + d_{f,ji}) \\
&= \frac{\beta c^s_i}{(1 + \tau^s_{l,i}) w_i} \cdot \left\{ I^s_i \frac{X_j}{P_j^{1-\epsilon}} \left(\frac{\epsilon}{\epsilon - 1} \frac{t_{ji} c^s_i}{1 - \tau^s_{y,i}} \right)^{-\epsilon} \frac{\mu^\theta \theta}{\theta - (\epsilon - 1)} \left(a^s_{ji}\right)^{\theta - (\epsilon - 1)} + f_{ji} I^s_i \mu^\theta \left(a^s_{ji}\right)^\theta \right\} .
\end{aligned}
$$

And the total labor demand in city i is the sum of labor by all destinations and types of firms, plus the labor used to cover fixed costs of entry

$$L_{d,i} = \sum_{j=1}^{N} \sum_{s=s,n} L_{ji}^{s} + M_i f_e \left(\frac{P_i}{w_i}\right)^{1-\beta} \cdot \left(\frac{\beta}{1-\beta}\right)^{1-\beta}.$$

The last term is the labor requirement for an un-distorted input bundle.

A.2.2 Taxes, Income, and Expenditure

Denote the disposable income in city i as Y_i. The total expenditure of city i, X_i, is then final spending by the consumers, plus expenditure on intermediate goods:

$$X_i = Y_i + (1-\beta)((1-\tau_{y,j}^{S})X_j^S + (1-\tau_{y,j}^{N})X_j^N).$$

Note that expenditure is proportional to income. Without any distortions, income is simply $w_i L_i$. However with both distortions:

$$Y_i = w_i L_i + \sum_{d=s,n} \sum_{j=1}^{J} \tau_{l,i}^{d} w_i L_{ji}^{s} + \sum_{d=s,n} \sum_{j=1}^{J} \tau_{y,i}^{d} X_{ji}^{s},$$

where L_{ji}^s is the labor demand, including those used to cover both the variable and the fixed costs of production, of selling to market j, and X_{ji}^s is the sales revenue generated from city j. Note that when $\tau_{\{\cdot\}} > 0$, it generates a positive tax revenue, and then the local government repays back to the workers in lump-sum. Similarly, when $\tau_{\{\cdot\}} < 0$, the local government runs into deficits due to the subsidies, and thus levies lump-sum tax to balance the budget.

B Tables and Figures

Table B.1: Provinces in Regions

East	Northeast	Middle	West
Hebei	Liaoning	Shanxi	Chongqing
Shandong	Jilin	Inner Mongolia	Sichuan
Jiangsu	Heilongjiang	Anhui	Guizhou
Zhejiang		Jiangxi	Yunnan
Fujian		Henan	Tibet
Guangdong		Hubei	Shaanxi
Hainan		Hunan	Gansu
		Guangxi	Qianghai
			Ningxia
			Xinjiang

Note: We divide mainland China into 4 different regions