Spatial Misallocation across Chinese Firms

Xiaolu Li Lin Ma Yang Tang [*]

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Abstract

We document the spatial variations of firm-level frictions across cities in China and quantify their macroeconomic implications. Larger and centrally-located cities are less distorted in both the output and the factor market. The firm-level frictions lower the aggregate income by 10.5 percent in 2007, and over 50 percent of the welfare cost is due to the spatial dispersion of the frictions. The spatial dispersion of the frictions also increases spatial inequality by around 5 percent, as it suppresses economic activity in small cities.

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

JEL Classification: F12;O11;R12

[*]Respectively: Nanyang Technological University (li0005lu@e.ntu.edu.sg); National University of Singapore (ecsml@nus.edu.sg); Nanyang Technological University (tangyangs@ntu.edu.sg). The authors are grateful for the stimulating discussions with Wen-Tai Hsu, Zheng Michael Song, and Cheng Wang. We have also greatly benefited from the valuable suggestions and comments received from various seminars and conferences at Chinese University of Hong Kong, Nanyang Technological University, the 2016 Taipei International Conference on Growth, Trade and Dynamics, the 2016 Econometric Society China Meeting. We are solely responsible for any remaining errors.

1 Introduction

Frictions at the microeconomic level can be costly: they affect firm-level decisions, distort resource allocation, and lower aggregate productivity.[1] Many studies on the micro-level frictions focus on the cross-country differences and show that these frictions are rooted in the differences in institutional quality, geography, and infrastructure investment. Similar to the international context, the underlying factors that cause the micro-frictions also vary drastically across regions within the same country. The spatial dimension of the micro-level frictions can influence the distribution of economic activities across regions; the resulting spatial misallocation might then lower the welfare at the national level. In this paper, we study the spatial dimension of the micro-level frictions in the case of China. We first document that the micro-frictions vary systematically across cities and explore the roots of the spatial variation; we then quantify their macroeconomic implications through a general equilibrium framework and evaluate policies that can mitigate the adverse effects of the spatial misallocation.

We first show that the micro-frictions vary substantially across cities. Following the methods in Hsieh and Klenow (2009), we estimate the output and labor frictions in each prefecture-level city in China between 1998 and 2007. Cities at the 75th percentile of output frictions are subjected to frictions equivalent to a 6.1 percent sales tax, while those at the 25th percentile are subjected to significantly lower friction at -1.6 percent tax-equivalent. The 7.7 percentage points spread between the 75th and the 25th percentile is roughly 5 times the national median of 1.6 percent. The spatial dispersion of labor frictions is even higher: the 75-to-25 spread of labor frictions is equivalent to 43.2 percentage points in payroll taxes, roughly 20 times of the national median of 2.1 percent. Moreover, the spatial variations are persistent as well. While both frictions decline at around 0.3 to 0.4 percentage point per year, the spatial dispersion remained approximately constant as the reductions tend to be uniform across cities.

Among many factors, city size, location, and the presence of State-Owned Enterprises (SOEs) are the main culprits of the spatial variations of the frictions. Larger cities are less

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

distorted than smaller ones in both frictions. Doubling the population reduces the absolute values of the output (labor) frictions by 1.3 (2.5) percent tax-equivalent, which is roughly 81 (120) percent of the median level of the frictions. Cities located closer to the center of the transportation networks enjoy lower output frictions. In contrast, the relationship between network centrality and labor frictions differs by the type of the firm. SOEs in centrally-located cities enjoy lower labor frictions, but private firms in similar locations suffer higher labor frictions instead. Similarly, higher SOE employment share leads to lower frictions among SOE firms but higher frictions among private firms on both measures. The explanatory power of city size and location suggests that output frictions are influenced by the ease of market access, transportation costs, and the size of the local market as well. The diverging impacts on the labor frictions, on the other hand, are probably because larger and more centrally-located cities often enact stricter rules to regulate migrant workers, and the rules probably apply differently to SOEs and private firms.

To quantify the impacts of the spatial misallocation, we turn to a spatial general equilibrium model. Our model follows the ideas of Melitz (2003), Eaton et al. (2011), and Di Giovanni and Levchenko (2012) and it allows for heterogeneous firms, inter-city trade, and endogenous firm entry and exit decisions. The output and labor frictions vary by location and the types of firms, be it SOE or private. The firm-level frictions manifest themselves in the aggregate outcomes through multiple channels. Within each city, the frictions distort the decisions of the firms in both the factor and the output markets, as well as the entry and exit margin. Across cities, the micro-frictions permeate through inter-city trade. We quantify the model to 279 prefecture-level cities in China in 2007. The structural parameters are chosen to match the moments in the firm-size distribution, the internal trade volume, and the employment share of state-owned firms in the data. We also take into account the relative 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 of frictions in one city affect all the other cities via the inter-city trade, and the magnitude depends on their relative positions on the transportation network. Our benchmark calibration successfully matches several key untargeted moments in the data, such as the distribution of output and operating firms across cities.

Before turning into the spatial implications, we first show that similar to previous work, firm-level frictions lower aggregate welfare in our model as well. Eliminating all the frictions in 2007 leads to a sizable increase in the aggregate welfare (10.5 percent). The aggregate gain is probably rooted in the fact that the existing frictions favor relatively unproductive SOEs. Without the frictions, 12.6 percent of workers relocate towards the private firms and the number of operating SOEs decline as well.

The novelty of our model to the literature is that it allows us to single out the impacts of the spatial distribution of the frictions. To this end, we convey two messages: 1) the spatial disparity of the frictions explains around half of the aggregate cost of the frictions; 2) the spatial disparity also leads to higher spatial inequality. To disentangle the impacts of spatial misallocation, we equalize the frictions in all the cities to the national average level and re-simulate the model. To a researcher that is only measuring the frictions at the national level, this counter-factual world is identical to the baseline world in which the frictions are distributed unevenly across space. However, the aggregate welfare is different between the two worlds. Equalizing the frictions across space results in a 5.7 percent gain in the aggregate welfare, or $5.7/10.5 \approx 54.2$ percent towards the total gain in the frictionless case. The spatial dispersion of the frictions is costly because it diverts the economic activity away from small cities due to the advantages of large cities in both frictions. Without the spatial dispersion, existing firms expand, and new firms enter in the small cities, leading to a substantial welfare gain. Our first message suggests that the spatial variation of the frictions within a country is an under-studied and yet important source behind the observed productivity differences across countries.

In addition to its toll on aggregate welfare, the spatial disparity of the frictions also leads to cross-city inequality. Removing the frictions lowers spatial inequality by 4.1 to 5.4 percent as measured by the coefficient of variation or standard deviation of the logarithm of city-level real income. The reduction in inequality occurs at both tails of the city size distribution: the 90-to-50 percentile ratio in the city size distribution drops by 7.3 percent, while the 50-to-10 percentile ratio falls by 6.3 percent. The impacts on inequality are mainly due to the spatial distribution of the frictions. As larger and more centrally located cities are less distorted, smaller cities stand to benefit relatively more in a frictionless world, leading to the reduction of spatial inequality.

Lastly, we evaluate the potential policies that can mitigate the negative impacts of the spatial misallocation. Our empirical results highlight the importance of the transportation network in lowering output frictions. We first back-out the implied reductions in the frictions if the internal trade costs are lowered by 1 percent using our reduced-form results; we then quantitatively evaluate the impacts of the trade costs reduction and the implied improvements in the spatial misallocation. A 1-percent internal reduction in trade costs improves aggregate welfare by 1.46 percent without the adjustments in micro-frictions. The resulting improvements in output frictions further amplify the "gains from trade" by 0.68 percent.

Our paper is closely related to the literature on micro-level frictions and resource misallocation Restuccia and Rogerson (2008); Hsieh and Klenow (2009); Buera et al. (2011); Guner et al. (2008); Hopenhayn (2014). In the context of China, Tombe and Zhu (2015) study how misallocation due to goods and labor market frictions affect the aggregate productivity at the province level. Brandt et al. (2013) measure the reduction in the aggregate non-agricultural TFP due to labor and capital distortions across provinces and sectors for the period 1985-2007. Brandt et al. (2017) emphasizes the role of entry barriers in regional income growth. Hsieh and Moretti (2015) also highlight the role of housing constraints on the spatial misallocation of economic activities. Song and Wu (2015) and Wu (2018) focus on the capital misallocation behind the micro-frictions among Chinese firms, and we focus on the output and the labor dimensions instead. We contribute to this literature by highlighting the spatial dimension of the frictions. We first document the pattern of dispersion across cities and how they correlate with city-level characteristics. We also show that the dispersion of the frictions across cities in itself is costly to both aggregate welfare and spatial inequality.

Our work is broadly related to the vast 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. We show that the spatial dispersion of frictions both within and between cities can contribute to the regional income differences. Reforming the output and factor markets will lead to improvements in both the aggregate welfare and spatial income inequality.

The rest of this paper is organized as follows: Section 2 presents the theoretical framework and defines the frictions. We discuss the estimation strategies and results 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 internal trade, heterogeneous firms, and endogenous firm entry/exit decisions similar to Di Giovanni and Levchenko (2012).

The economy contains $J > 1$ geographically segmented cities, indexed by $j = 1, 2...J$. Workers are all identical, and we denote the population size in city j as L_j. We do not allow inter-city migration. Workers residing in city j obtain utilities from consuming the set of varieties available in city j:

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

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 as well as all the locally available varieties as inputs 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. We do not directly model capital in the production function. Instead, we assume capital goods to be part of the composite varieties and take the user costs of capital into consideration when estimating the micro-level frictions in the next section.

Firms are heterogeneous regarding 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.[2] Upon entry, firms draw the input bundle requirement a from a Type-I Pareto distribution:

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

where $1/a$ implies firm productivity, θ is the tail index and μ captures the lower bound of the firm productivity distribution. It is then straightforward to show that the input bundle requirement a follows a distribution function $G(a) = (\mu a)^{\theta}$.

Two types of firms exist in the economy: state-owned enterprises and private firms. Firms do not know their types before entry. Upon entry, they draw their input bundle requirement and type independently at the same time. With probability $\lambda_i \in [0,1]$, the firm in city i becomes state-owned, which we denote as type S, and with probability $1-\lambda_i$, the firm becomes private, which we denote as type N. At the entry stage, the entry cost is undistorted since firms have not realized their types. Afterward, they will produce subject to the frictions of their types.

Given the realization of its type and productivity, each firm makes production decisions. For a firm from city j to sell to the market in city i, fixed operating costs f_{ij} in the unit of input bundles in city j need to be paid. Moreover, standard iceberg trade costs also apply: to deliver 1 unit of variety from city j to city i, firms need to ship $t_{ij} \geq 1$ units from city j.

Frictions We follow Hsieh and Klenow (2009) to 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 in-

[2]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 the equilibrium, the entry costs will also differ in value.

nocuous: 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.

The "labor frictions", or τ_ℓ, are the frictions that affect the marginal product of labor relative to composite varieties. Intuitively, a firm needs to pay $(1+\tau_\ell)$ times of the market wage rate to hire one unit of labor to produce. 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 distort the unit cost of the input bundle for type-d firms in city j:

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

where w_j is the market wage rate and P_j is the price of composite variety in city j. The above result is the solution of 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 optimal inputs composition of the firm, but not necessarily the size of the firm.

The "output frictions", or τ_y, directly take a "hair-cut" on the sales revenue of firm k:

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

where $\sum_{i=1}^{J}p_i^d(k)\,q_i(k)$ is the firm k's sales revenue and $a(k)\,c_j^d\sum_{i=1}^{J}t_{ij}q_i(k)$ is the cost of production after adjusting for the iceberg trade costs t_{ij}. We interpret the output frictions as results of sales revenue tax/subsidy or policies that excessively regulate the product market or institutional inefficiencies such as the lack of contract enforcement or the 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 theoretically isomorphic to payroll and revenue "taxes" or "subsidies", we directly treat them as so to close the model. Positive labor or output frictions bring tax revenue to the government, and negative frictions cause 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, which we will discuss in details 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 government budget-to-output ratio.

The "taxes", "subsidies", and the "government budget" in this paper are constructed theoretically to measure the size of the distortions. They are neither intended to nor can they be, matched to their counterparts in the data. Since we do not intend to study the fiscal issues of local governments in China, and thus none of these fiscal terms in this paper shall be interpreted literally.

2.1 Firm's decision

Price and Sales Destinations Denote X_i to be the total expenditure on the 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 models with heterogeneous firms 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 decide whether it is profitable to sell to city i:

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

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:

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

Finally, the ideal price index for composite variety in city i is:

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

Entry and Exit There are infinitely many potential firms in each city and entering firms can freely exit the market. Free entry implies that in the equilibrium, the expected profit from entry should equal the entry costs in each city. Specifically, the free entry condition in city j is:

$$\lambda_{j}\sum_{i=1}^{J}\mathbf{E}\left[\pi_{ij}^{S}\left(a\right)\middle|a<a_{ij}^{S}\right]+\left(1-\lambda_{j}\right)\sum_{i=1}^{J}\mathbf{E}\left[\pi_{ij}^{N}\left(a\right)\middle|a<a_{ij}^{N}\right]=f_{e}\bar{c}_{j}, \tag{1}$$

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

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

Although neither output nor labor frictions directly influence the unit cost of the input bundle at the entry stage, they nevertheless affect the entry and exit decisions of firms in the general equilibrium through the factor and the output prices.

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 the consumption of each variety.

2. Firms maximize their profits by choosing the price and quantity for the variety sold to each market.

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:

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

5. The labor market clears in each city:

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

where:

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

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

Appendix A provides more details on solving the model.

3 The Estimation of the Frictions

Guided by the model, we estimate the frictions at the city level by aggregating the firm-level frictions and map them to their model counterparts. We repeat this exercise for each year between 1998 and 2007 to construct a panel dataset and study the spatial dispersion of the frictions.

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 every 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 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 locate the firms by zip codes and restrict our analysis to those in the 279 prefecture-level cities that are 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 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 in these cities comprises approximately 98.1 percent of the entire sample in the *Annual Surveys* as well.

We first clean the data by several standard procedures. We drop the firms whose sales 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 industries such as energy, telecommunication, and heavy industrial equipment remained.

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 among type d firms. Although at the aggregate level labor is the only factor of production in our model, the production function at the firm level still requires two inputs: labor and composite varieties. As a result, each firm in our model faces a non-trivial cost-minimization problem, which allows us to map the model to the data and separately identify the output and labor distortions. The readers may refer to Hsieh and Klenow (2009) for the details of the procedure. We mainly focus on the estimation results in this section.

Solving firm k's cost minimization problem leads to the following estimate of the labor frictions, $\tau^d_{\ell,j}(k)$:

$$\tau^d_{\ell,j}(k) = \frac{\beta_{m(k)}}{1-\beta_{m(k)}} \cdot \frac{P_j Y^d_j(k)}{w_j L^d_j(k)} - 1,$$

where $m(k)$ is the industry to which firm k belongs and $\beta_{m(k)}$ 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 user cost of capital. We compute the cost of capital as the depreciation cost of the total asset plus the cost of financing, which in turn equals the total assets times the risk-free interest rate.[3] All the variables are observable in the data, and thus the estimation is straightforward. Our estimated "labor frictions" are the costs of labor relative to the intermediate inputs that include capital. High levels of "labor frictions" can be a result of high barriers in the labor market or a result of low barriers in the intermediate goods and capital markets as well.

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

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

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

We allow labor intensity, β_m, to vary across 491 industries at the 4-digit level, and use the *Annual Surveys* to estimate it.[4] We define the labor intensity in each industry as the ratio of total wage bill to the total expense in our baseline estimates and provide robustness checks in the appendix with an alternative definition using the ratio between total wage bill and sales revenue. Besides, the industry-specific β_m also implies that the differences in the estimated frictions between SOEs and the private firms are *within-industry* differences, and thus industry-specific characteristics will not distort our estimates.

We aggregate up the firm-level frictions to estimate the city-ownership frictions as the weighted average across firms:

$$\begin{aligned} \tau_{\ell,j}^d &= \sum_k \tau_{\ell,j}^d(k)\,\omega_{jl}^d(k), \\ \tau_{y,j}^d &= \sum_k \tau_{y,j}^d(k)\,\omega_{jy}^d(k), \end{aligned}$$

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.

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

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

We also estimate the city-specific frictions, $\tau_{\ell,j}$ and $\tau_{y,j}$ following similar manner. Instead of using the weighted average within each city-ownership cell, we compute the city-specific frictions based on the weighted average within each city:

$$\begin{aligned}\tau_{\ell,j} &= \sum_k \tau_{\ell,j}(k)\,\omega_{jl}(k)\,,\\ \tau_{y,j} &= \sum_k \tau_{y,j}(k)\,\omega_{jy}(k)\,.\end{aligned}$$

3.3 Estimation Results

Table 2 reports the summary statistics of the estimated frictions at the city level in each year, $\tau_{\ell,j}$ and $\tau_{y,j}$. The output friction across the entire sample equals 0.027 on average, which is equivalent to a 2.7 percent sales tax. The labor friction on average is 0.072, equivalent to a 7.2 percent payroll tax. Throughout the years, the national median of each friction is always smaller than the mean, suggesting that the distributions across the cities skew to the right, and some cities experience particularly high frictions. The frictions exhibited large variations across the cities. The 75 percentile of output frictions across cities was 6.1 percent sales tax equivalent, while the 25 percentile was 7.7 percentage points lower at -1.6 percent in 2007. Labor frictions exhibited larger spread: cities at the 75 percentile faced labor frictions equivalent to 27.7 percent payroll taxes while cities at the 25 percentile enjoyed a -15.5 percent payroll tax in 2007, 43.2 percentage points lower than those at the 75th percentile. The spatial spread of both frictions is also persistent across the years. For example, the 75-25 spread of output frictions was $9.1 - (-2.5) = 11.6$ percent in 1998, and of labor frictions $25.5 - (-13.4) = 38.9$ percent in the same year.

Table 3 reports the regressions of the city-specific frictions against the logarithm of the population in each city in the upper panel, and GDP in the lower panel. We use the absolute values of the distortions on the left-hand-side, as both positive and negative deviations from zero are potential indicators of misallocation. The first column only includes the city size on the right-hand side, and it shows that larger cities are less distorted. Doubling the population decreases the output frictions by 1.4 percentage points, which is roughly half of the national average of 2.7 percent over the years. Similarly, doubling the population decreases the labor frictions by 2.7 percentage points, roughly one-third of the national average of 7.2 percent. The second column adds the linear time trend to the RHS. Both frictions are declining in absolute values by around 0.3 percentage points per year, suggesting the micro-level frictions have been improving over time. However, the relationship between city size and frictions is unaffected by the inclusion of the time trend: the point estimate on city size only moves from -0.014 to -0.013 in the case of output frictions, and from -0.027 to -0.025 in the case of labor frictions. The insensitivity of the city size coefficient to time trend suggests that the gaps in frictions between large and small cities stayed roughly the same over the years. The third column confirms the persistence of the gaps: the interaction between city size and the time trend is not significantly different from zero for both frictions. Column 4 introduces the year fixed effects and column 5 includes both year and city fixed effects to the RHS of the estimation.[5] The time fixed effects barely change the estimates. However, the coefficients on city size are no longer significantly different from zero once we introduce the city fixed effects. This suggests that the micro-frictions are probably rooted in the time-insensitive city characteristics such as institution quality or the geographic locations that correlate with city size, and the micro-frictions are not alleviated by economic growth over time. The results based on city-level GDP instead of the population are qualitatively the same.

The reason that large cities are less distorted might be attributed to many factors. Larger cities enjoy better infrastructure and access to markets, which tend to improve productivity. Moreover, firms in larger cities might obtain better managerial practices, which also tend to reduce output frictions. In addition, the agglomeration effects from city size may also possess certain explanation power. Finally, larger cities are also able to sustain thicker labor markets that reduce search frictions, which in turn lower the estimated labor frictions. The finding that both output and the factor markets are less distorted in larger cities also offers another explanation of the productivity premiums in large cities, which is often documented in the urban literature (Hendricks, 2011; Combes et al., 2012; De la Roca and Puga, 2017).

Table 4 reports the evolution of the frictions over time. Similar to Table 3, we use the absolute values of the frictions on the LHS. The first column reports the regression against

[5]We use the methods introduced in Correia (2017) to estimate the fixed-effects model. The estimation procedure drops the singleton observations, resulting in the differences in the number of observations between the fixed-effect model and the rest of the table.

a linear time trend, and the results confirm an overall reduction of the frictions over time. The second column replaces the linear time trend with year dummies. Output frictions have been decreasing over the years steadily. Most of the reduction in labor frictions occurred around 2004 and 2005, and the frictions reverted to around 1998 levels by the end of the sample as seen in Table 2. The last column introduces city fixed effects in addition to the year dummies. The point estimates on year dummies are mostly unaffected, suggesting again that cities experienced similar trends of frictions over the years.

The frictions also differ within cities between the SOEs and the private firms. Table 5 reports the regressions with the within-city differences between SOEs and private firms on the LHS. The first column reports the regression with only the constant on the RHS. On average, the SOEs suffer higher output frictions that are equivalent to an additional 5.3 percent sales tax over the years. The second and the third columns suggest that the disadvantage among SOEs are slowly vanishing at around 1.1 percent points per year, and the SOEs have caught up with private firms at a faster pace after 2004. The improvement of SOEs relative to the private firms 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 of SOEs worsened in the 1990s due to the ever-increasing competition from the private and foreign firms. In 1998 as many as 15 percents of the SOE firms reported a loss, while the corresponding statistics for the private firms is only 3.5 percent as documented in the *Annual Surveys*. In order to resolve these issues, the central government initiated a new wave of reforms that involved large-scale layoffs, 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 the return to assets, increased from 0.04 to 0.14.[6] The improvements in efficiency ultimately showed up as the reduction in output frictions

[6]Source: the authors' calculations using the *Annual Surveys*.

relative to the private firms in our estimation.

The SOEs enjoy significantly lower labor frictions equivalent to a 28.7 percentage points reduction in payroll taxes. The advantage of SOEs in the labor market is prevalent in almost all cities as shown on the map in Figure 1, and it is persistent over the years. SOEs usually enjoy a better relationship with local governments, and thus are adept at navigating through the bureaucratic hurdles to secure work permits and household registrations requirements for their workers.

3.4 Source of the Frictions

To explore the underlying forces behind the spatial variations of the frictions, we decompose the estimated frictions against several groups of city characteristics. All the city-level data come from *China City Statistical Yearbooks*. In general, we classify our city-level variables into the five categories: 1) **location and transportation**, which includes the measures of the centrality of a city in the transportation networks based on Ma and Tang (2016)[7], per-capita length of paved road, the volume of freight and passenger transportation; 2) **finance**, which includes the total amount of household deposits; 3) **foreign direct investment(FDI)**, which includes including the contracted FDI and the actual FDI; 4) **real estate development**, including the total investment in real estate sector and the total residential investment, and 5) **governance**, which includes government income and government expenditure. We regress the estimated frictions against the aforementioned variables and control for population, share of SOE employment, share of SOE sales revenue as well as year fixed effects at the same time. The results are summarized in Table 6. As the location variables rarely vary over time, we do not include city fixed effects in the regressions. To this end, the results reported in the table are driven by cross-city variations within each year.

The location of the city is a robust determinant of the city-level frictions. Cities located closer to the center of the transportation network enjoys lower output frictions. For example, a 1-percent increase in centrality leads to a 0.131 percent decrease in the output frictions

[7] The centrality of a city is the inverse of the average geographic transportation costs to all the other cities. Higher centrality means a city is close to all the other cities. The geographic transportation costs are estimated based on the railroad, national way and highway, and waterway transportation. For details, see Ma and Tang (2016).

at the city level, and a 0.183 (0.117) percent decrease among the SOE (private) firms. The negative correlation between centrality and the output frictions suggest that part of the observed decrease in output efficiency is due to the (lack of) access to transportation infrastructure, which might, in turn, leads to the difficulties in reaching consumer markets or downstream producers along the production network. The relationship between location and the labor frictions, on the other hand, differs by the type of firms. More centrally-located cities see lower labor frictions among SOE and higher frictions among private firms. The opposing effects might also be the results of labor market regulations that we have discussed earlier. Centrally-located cities tend to be popular destinations of migration, and as a result, tend to enact stricter barriers to deter immigration. The private firms are particularly sensitive to the restrictions in the labor market, as they have a comparative disadvantage in securing work permits and Hukou as compared to their SOE counter-parts. The other variables cannot robustly explain the spatial variations in the frictions.

To further quantify the explanatory power of various city-level characteristics, we also compute both the bi-variate and the partial R-squared by the groups of the variables. The bi-variate R-squared of group k is based on the regression where only group k variables are included on the right-hand-side of the regression. The partial R-squared of group k is derived from the changes in the explanatory powers when the group is excluded from the regressors.[8] We summarize the decomposition in Figure 2. Consistent with the findings above, the location and transportation variables can explain the largest fraction of the variations in both the output and the labor frictions. The partial R-squared of the other groups of variables is close to zero.

4 Calibration

We calibrate the model into the Chinese economy in 2007. We focus on the 279 prefecture-level cities discussed in the previous section (Figure 3). Given the estimated output and labor frictions, our parameter space contains: $\{\varepsilon, \theta, \mu, \beta, f_e\}$, the population distribution

[8]The partial R-squared is defined as $\frac{R^2 - R^2_{-k}}{1 - R^2_{-k}}$, where R^2 comes from the full model with all the regressors, and R^2_{-k} comes from the model without group-k variables.

$\{L_j\}$, city-specific probability of becoming SOE $\{\lambda_j\}$ 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 $\theta/(\varepsilon - 1)$. We let θ be 5.3 so that the tail index equals 1.06, which is the value documented in Axtell (2001). β reflects the share of labor in total outputs. We take the average of the labor intensities over the 491 industries at the 4 digit level from the *Annual Surveys* as the average ratio of total wage bill to the total expense of production. β is estimated to be 0.3. 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.[9] We assume that the entry cost measured 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 the equilibrium, the monetary costs of entry indeed vary across cities as well. We calibrate this parameter to match around 340 thousand firms in Shanghai—the largest city in China.[10] λ_j governs the probability of becoming state-owned firms upon entry in city j. We obtain this value using the employment share of SOEs from the *Second Economic Census* in 2008. The data is at the provincial level, and we assign the same probability to each prefecture city within the province. Table 8 reports the list of calibrated λ_j in each province. The SOE employment share on average is about 34.83 percent. λ_j vary substantially across space as well; the highest share is 67.88 percent (Xinjiang), and the lowest share is only 3.99 percent (Zhejiang).

[9] 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.

[10] The data source is *the Second Economic Census* carried out in 2008.

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 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 7.

5 Quantitative Results

We evaluate the aggregate and the distributional impacts of micro-level 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 then study the impacts of the spatial distribution of the frictions by only eliminating the variations of them across cities. In addition, we also examine the impacts of the within-city distributions of frictions by eliminating the differences between SOEs and private firms in each city. We then provide a discussion on the role of firm entry in determining the resource allocation. Lastly, we study the impacts of frictions over time between 1998 and 2007. The results of these counter-factual simulations are summarized in Table 9.

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 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 tax revenue collected due to the frictions is negative, the local government is running a deficit, and thus 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 disposable income(GDP):

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

Our model fits some untargeted moments as well. The left panel of Figure 4 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 (2008)* with the number of operating firms in our model. Again, the model has successfully mimicked the data pattern with a correlation of 0.94.

5.1 Impacts of Frictions in 2007

Column 1 in Table 9 reports the baseline results using the estimated frictions. All the distortions in 2007 lead to a deficit equivalent to 5.9 percent of the aggregate nominal GDP. Output frictions are slightly positive among SOEs at around 2.0 percent of nominal GDP, and negative at -2.4 percent among private firms. The local governments subsidize labor input at around 7.6 percent, whereas tax labor input in private firms at around 2.1 percent of nominal GDP. These together imply a deficit equivalent to 0.3 percent of nominal GDP from private firms, and a deficit equivalent to 5.6 percent from SOEs. The disadvantage of SOEs in the output frictions, together with the favorable labor subsidy towards them hints that the frictions might be costly: the labor subsidies among SOEs draw workers away from the more productive private firms that enjoy lower output frictions.

Similar to the findings in the literature, the microeconomic frictions lower the aggregate welfare in our model as well. We quantify the impacts of the frictions by running a counterfactual exercise in which all the frictions are set to zero. The second column in Table 9 reports the results. Removing all the frictions leads to a $282.27/255.37 - 1 \approx 10.5$ 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 has dropped from 47.2 percent to 34.6 percent, and the number of operating SOEs has dropped by $1 - 57.97/59.02 \approx 1.8$ percent. In contrast, the private firms benefit in the frictionless economy: their employment share has increased from 52.7 to 65.3 percent, and the number of operating firms has increased by $215.54/208.26 - 1 \approx 3.5$ percent.

The firm-level frictions also increase spatial inequality. Once removed, the coefficient of variation in city-level real income has decreased by around $1 - 2.38/2.52 \approx 5.4$ percent, and the standard deviation of the logarithm of real income by around $1 - 1.16/1.20 \approx 4.1$ percent. The reduction in spatial inequality can be observed across the city size distribution. The 90-to-50 percentile ratio drops by 7.3 percent from 5.04 to 4.67 and the 50-to-10 percentile ratio, by 6.3 percent from 4.19 to 3.92. The reduction in the spatial inequality is probably because larger cities are less distorted than smaller ones, as shown in Section 3, and thus are expected to benefit less from the removal of the frictions. Figure 5 panel (a) shows that it is indeed the case: a 10-percent increase in city size is associated with 0.5 percentage point lower gain in real GDP between the baseline and the frictionless economy.

The majority of the cities benefit in the frictionless economy. The city that gained the most sees its real income increased by as much as 95.93 percent. On the other hand, not all the cities benefit from the removal of frictions: 11 cities suffered *loss* in real income once the frictions are removed, and the largest loss is about 5.6 percent. The percentage gain/loss from the frictions is aligned with the distortion implied, as seen in Figure 6. The cities that benefit most from the frictionless economy are those the see large reallocation between the SOEs and the private sectors. The "losing" cities are those that experience approximately zero labor or sales reallocation from the removal of the frictions. Moreover, the SOE sector only expands in a few cities, and most cities benefit from an increase in employment and sales share of private firms.

Removing all the frictions also lowers the inter-city trade share from 0.623 to 0.617. We will provide more intuition on this finding later in the discussion of the spatial variations of the frictions.

5.2 The Spatial Variations of Frictions

In the previous section, we showed that the microeconomic frictions are costly at the aggregate level. In this section, we what to ask, to what extent is the aggregate costs of the frictions due to the spatial disparity in its distribution? To answer this question, we eliminate the spatial differences by setting the frictions in all city-type cells to their weighted average at the national level, where we use the number of operating firms in the baseline simulation as the weight. We also set $\lambda_i = 0.395$ in all cities to eliminate the differences in the relative weight of SOEs across cities, and it is based on the employment share between the two sectors at the national level in 2007[11]. The differences between SOE and private firms within each city remain, and the average size of the frictions at the aggregate level is also kept roughly the same as in the baseline. To an outside econometrician that is only observing the frictions at the national level, this counter-factual world is indistinguishable from our baseline model as the differences only exist at the spatial distribution of the frictions across regions. The comparison between this counter-factual and our baseline reveals the effects of the spatial variations of the frictions. Column 3 in Table 9 reports the results of this simulation.

The spatial dispersion of the frictions explains a large fraction of the aggregate welfare costs of the frictions and almost all of their impacts on the spatial inequality. Equalizing the frictions across cities increases the aggregate real income by around $269.90/255.37 - 1 \approx 5.7$ percent, which is about $5.7/10.5 \approx 54.2$ percent of the overall welfare gain in the frictionless case. This is a large fraction, considering that the aggregate size of the frictions is around 7 percent of the GDP, roughly comparable to the 5.9 percent in the baseline model. It suggests that the average level of frictions in itself only contributes to a small fraction of

[11] Data source: *China Statistical Yearbooks*

the aggregate impact, while the majority of the impact lies in the spatial dispersion of the frictions. The gain in the aggregate welfare is mainly channeled through the reallocation of economic activities to small cities. Larger cities have advantages in both output and labor frictions as compared to the smaller ones, which suppresses firm entry and sales in the smaller cities in the equilibrium through inter-city trade. Removing the spatial disparity allows more firms in the smaller cities to survive and expand, and thus gain in the aggregate welfare. A supporting evidence of the effects is the lowered trade openness reported in the last row in Table 9: when the disadvantages in frictions disappear, the consumers in small cities spend more on local varieties instead of relying on the "imported" products from the large cities, lowing the trade share from 62.3 percent in the baseline model to 61.7 percent in the counter-factual. Removing the spatial differences in frictions also lowers the spatial inequality to levels almost identical to the frictionless case. This suggests that similar to the aggregate welfare, almost all the spatial inequality caused by the frictions is rooted in the spatial differences of the frictions.

Friction reduction at the local level In our previous exercise, we uniformly adjusted frictions among all the cities. In this section, we explore the potential spillover mechanism by adjusting frictions only in one city at a time. We remove the frictions in Beijing and Shanghai separately and report the results in column 4 and 5 of Table 9.

Removing the frictions in Beijing improves the national welfare by $256.40/255.37-1 \approx 0.4$ percent. Beijing is undoubtedly the city that benefits most with a welfare gain at 5.46 percent compared to the benchmark case. Improvement in Beijing drives approximately $(18.28-17.33)/(256.40-255.37) \approx 92$ percent of the aggregate welfare gain. All the cities, nevertheless, still benefit from the removal of the frictions in Beijing. As shown in Figure 8 and 9, the magnitude of the benefits declines with the distance to Beijing. While Chengde, a city in the nearby Hebei province gains 0.3 percent in real income, Shenzhen, a city all the way across the country next to Hong Kong only improves by 0.009 percent.[12]

We performed a similar exercise in the case of Shanghai, the largest city in China. Similar

[12]The aggregate size of the frictions moves from 5.9 to 5.5 percent of the GDP once all the frictions in Beijing are removed. This is because Beijing receives heavy labor subsidies in the baseline calibration. Without the subsidies, the aggregate frictions measured by government budget mechanically increase.

to Beijing, the overall welfare has improved by $255.87/255.37 - 1 \approx 0.196$ percent. The real income in Shanghai has improved by 1.715 percent, which is in turn 93.2 percent of the national gain. All cities benefit with the least improved city collecting a welfare gain at 0.001 percent, and the benefits decrease with the distance to Shanghai as well, as shown in Figure 8 and 9. The aggregate gain in the case of Shanghai is smaller than that in Beijing because Shanghai is less distorted in the baseline calibration.

The impacts of local frictions also permeate through inter-city trade: 1) removing frictions lowers the marginal costs of production for the firms in Beijing and Shanghai, which benefits all firms in other cities that use the outputs of these firms as intermediate goods, and 2) with lower frictions, firms in Beijing and Shanghai expand, which results in higher demand for the goods produced in all the other cities. Inter-city trade also explains why the benefits decrease with distance. Cities located closer to Beijing can benefit more from the friction reductions. However, the spillover depends not only on the bilateral trade costs but also on the ease of access to other large markets—an argument similar to the "multilateral resistance" proposed in Anderson and van Wincoop (2003) in the context of international trade. For example, cities to the southeast of Beijing usually benefit much less than northeastern cities with similar distances to Beijing, as shown in the left panel of Figure 8. This uneven effect is probably because the southeastern cities have easy access to Shanghai, which lowers the fraction of products imported from Beijing in their input bundles. Beijing is the only sizable economic center in northern China, which means that the cities to the north of Beijing rely heavily on the inputs produced there, and thus benefit more from the friction reduction in Beijing.

5.3 Non-Spatial Variations

In addition to the spatial variations, we carry out several other sets of counter-factual analysis to highlight the roles of within-city differences and firm entry/exit.

Within-city differences To single out the effects of the within-city dispersion of frictions, we conduct a set of counter-factual analysis in which we only eliminate the differences of the frictions between SOEs and private firms within each city. Instead of using the city-type specific frictions, we use the city-specific frictions estimated in Section 3. Column 6 of Table 9 reports the results.

Removing the within-city difference leads to a $273.03/255.37 - 1 \approx 6.9$ percent increase in real income, which is around $6.9/10.5 \approx 65.7$ percent of welfare gains in the frictionless case. The fact that within-city and between-city differences together explain more than 100 percent of the welfare gain towards frictionless economy suggests that there exist positive interactions between the two sources. Without the within-city differences, part of the spatial differences in frictions along with the spatial difference in λ_i is also removed at the same time, leading to substantial gains in the aggregate welfare. [13] Our results echo the findings in the literature on the Chinese economy that the distortions induced by the SOEs impose a sizable cost on aggregate outcomes, such as in Song et al. (2011) and Hsieh and Song (2015).

Firm Entry/Exit

Recent literature highlights the interaction between firm entry and resource misallocation, as in Yang (2016) and Brandt et al. (2017). Our quantitative results confirm their findings. The number of operating firms has increased by $273.5/267.3 - 1 \approx 2.3$ percent between the frictionless and the baseline simulations. The entry of firms affects the aggregate welfare through the ideal price index, or the "love of variety" effect commonly found with CES utility functions. At the city level, the impacts of the extensive margin are also evident: the cities that benefit tend to be those that experience higher growth rates in the number of entering firms and lower price index, as seen in Figure 7.

To evaluate the effects of firm entry, we carry out another 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. When we shut down the channel of entry and exit, free entry condition no longer holds, and the total profits earned among all the firms may not equal to zero. We assume that the workers collect all the profits, and thus

[13] As workers cannot move across cities, removing within-city difference is enough to ensure that the allocations of the workers are the same as in the frictionless case as can be seen by comparing the employment share between this and the "Frictionless" column in Table 9.

the disposable income in city j, Y_j, becomes:

$$Y_j = w_j L_j + \Pi_j^S + \Pi_j^N,$$

where Π_j^S and Π_j^N denote the total profits earned by the SOEs and private firms from city j in the frictionless economy, respectively. The changes in Y_j, in turn, affect all the other endogenous variables in the general equilibrium.

Table 9 reports the results under the column "No Entry" in. As compared to the baseline results, the aggregate real income has improved by around $269.5/255.4 - 1 \approx 5.5$ percent when we fix the number of firms, implying that $1 - 5.5/10.5 \approx 47.6$ percent of the gain in real income is due to the changes in the extensive margin. The high explanatory power of the extensive margin is not surprising: Yang (2016) also finds that endogenous firm entry and exit can have significant impacts on how misallocation affects TFP through firm selections without the "love of variety" effects. Brandt et al. (2017) also document the importance of entry barriers in explaining the regional income differences in China.

5.4 Changing Frictions between 1998 and 2007

As reported in Table 2, both frictions improved slightly over the years: the output frictions decreased from 0.044 to 0.024, and the labor frictions further dipped from 0.085 to 0.078. At first glance, it is unclear how the evolution of frictions has affected the Chinese economy. To understand this, we turn to comparative statics between the two years to study the general equilibrium impacts of the changing frictions.

We simulate the model using the frictions estimated in the year 1998 while keeping all the parameters other than the λ_i the same as in the benchmark model. In the baseline results, we calibrate λ_i by matching province-specific SOE employment share in 2008 from *the second economic census*. We are reluctant to impose the same λ_i from the baseline simulation to the counterfactual in 1998, since the pronounced SOE reforms initiated in the late 1990s that inevitably affect the relative weight of SOEs. However, we do not have comparable data to calibrate λ_i in a similar manner to our baseline calibration either, as the economic census only started in 2004. Instead, we assume an identical λ_i across the cities and set it to be the aggregate SOE employment share in 1998, which is 81.1 percent from the *China Statistical Yearbooks*.

The last column in Table 9 reports the results with the frictions estimated in 1998. The magnitude of the distortions, measured as the implied deficit-to-GDP ratio, has increased from 1.8 percent to 5.9 percent between 1998 and 2007. The rise of "deficit" are mainly driven by the reduction of output "taxes" among the SOEs, which have decreased from 6.3 percent of the GDP in 1998 to 2.0 percent in 2007. The SOEs receive less favorable treatments to payroll in 2007 than in 1998: the labor subsidies shrunk from 8.6 percent to 7.6 percent of the GDP. The share of SOEs in the number of operating firms drastically decreased from 81.64 percent in 1998 to 22.08 percent in 2007, and SOE employment share decreased from 78 percent to 47.2 percent. The average firm size among SOEs has increased by around $(47.2/22.1)/(78.0/81.6) - 1 \approx 123.7$ percent over the years, which is consistent with the designated SOE reform policy "grasp the large and let go of the small".

The changes in frictions over the years had led to a $255.37/243.10 - 1 \approx 5.0$ percent gain in the aggregate welfare or 0.55 percent per year. The annual gain is a small fraction as compared to the economic growth in China over the same time span. This probably reflects the fact over the years, the spatial variations of the frictions remained unchanged. Table 3 shows that while larger cities are less distorted, the gap between large and small cities remained roughly the same across the years. Our counter-factual simulations also emphasized that it is the spatial differences of the frictions, not the average level of the frictions, that are responsible for the welfare costs.

The changes in frictions also seem to increase the spatial inequality slightly. The coefficient of variation decreased by 3.2 percent, from 2.60 to 2.52, and the standard deviation of the logarithm of real income increased by 0.5 percent, from 1.198 to 1.204.

5.5 The Role of Location and Transportation

Section 3.4 shows that the location and transportation network exert robust impacts on city-level frictions. In this section, we turn to quantify their roles at both aggregate and local level. At the extensive margin, a better location and transportation network promote internal trade and leads to the usual gains from trade. At the intensive margin, as shown in section 3.4, a well-connected city also enjoy lower output frictions for both types of firms[14]. In the following, we perform several quantitative exercises to evaluate the impacts of both margin.s We first reduce the ice-berg trade cost uniformly by 1-percent across all the city-pairs without altering the firm-level frictions. We then adjust the frictions based on the reduced-form estimations reported in Table 6.[15], given the same changes in the trade costs. The results are listed in Table 10.

One-percent reduction in iceberg trade costs leads to $259.1/255.37 - 1 \approx 1.46$ percent welfare gain. The inter-city trade as a fraction of total output has also grown from 0.623 to 0.635 due to lower trade costs. The impacts of trade are slightly amplified if we take into account the resulting changes in the city-level frictions. The welfare gain increase to $259.13/255.37 - 1 \approx 1.47$ percent, and thus the gain has increased by 0.01 percentage points, or $0.01/1.46 \approx 0.68$ percent. The amplification in welfare gain is due to the lower output friction and the declining labor frictions at SOE firms as suggested in Table 6. We further decompose the impacts of output and labor frictions separately and report the results in the following columns. The results show that improvements in transportation infrastructure lower the output frictions, and thus amplify the welfare gain from only lowering trade costs by $(259.13 - 259.11)/255.37 \approx 0.78$ percent. The implication is thus a better-connected transportation network can not only induce more internal trade but also enhances the production efficiency. Similarly, the welfare gain is enlarged by $(259.13 - 259.12)/255.37 \approx 0.39$ percent if only labor frictions are adjusted, potentially due to the negative relationship between location and labor frictions among private firms.

In all the cases, lower trade costs tend to reduce the number of operating private firms but encourages a higher employment share at private firms, which is equivalent to a larger size per private firm. This is likely because lower trade costs increase competition among firms at the local market, and drives the less productive firms out of the market. When we take into account the adjusted frictions, the number of operating firms slightly increase compared with the case where only trade costs decrease, and this is because output frictions

[14]However, lower trade costs also induce higher labor frictions among private firms. The impacts of this intensive margin thus remain ambiguous, and it calls for quantitative study.

[15]For example, as shown in Table 6, a 1-percent decrease in the ice-berg trade cost will lower the absolute output friction of SOEs by 0.183-percent. We thus adjust benchmark τ_y^s according to this percentage change.

drop as shown in Table 6. Our results also suggest lower trade costs tend to reduce the spatial inequality by around 0.0397 when we measure it by the coefficient of variation.

6 Conclusion

In this paper, we study the spatial component of firm-level frictions. We show that the frictions in both the factor and the output markets vary systematically across cities, and the spatial disparity is persistent over time. Larger and better-connected cities enjoy relatively lower frictions; higher concentrations of SOE improve the frictions facing the SOEs while at the same time, worsen the frictions facing the private firms. We then evaluate the aggregate impacts of the frictions through a general equilibrium model. We show that the firm-level frictions impose a cost at the aggregate level equivalent to 10.5 percent of the real outcome, and meanwhile increase the spatial inequality by around 4 to 5 percentage points. Roughly half of the aggregate welfare costs and almost all of the impacts on spatial inequality are due to the spatial dispersion of the micro-level frictions.

A couple of caveats exist in interpreting our results. We refrained from adding within-country labor mobility as in Tombe and Zhu (2015) and Ma and Tang (2016); our analysis is focused on manufacturing firms in the urban area, and thus ignores the agriculture and rural workers. The elements mentioned above deserve intensive and careful study as much as the factors that we focus on in this paper. We choose to study and present the essential patterns of spatial misallocation in this paper and highlight the importance of the spatial distribution of the frictions. We leave the incorporation of the factors mentioned above to future work.

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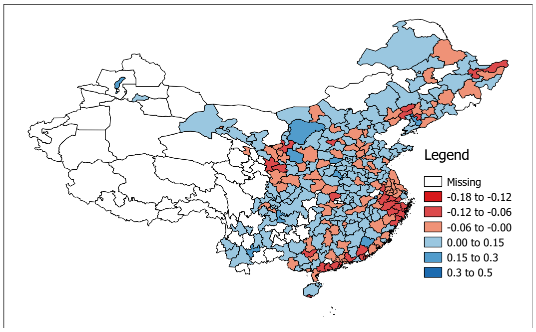
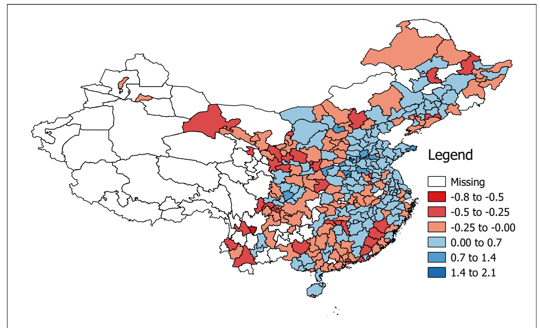
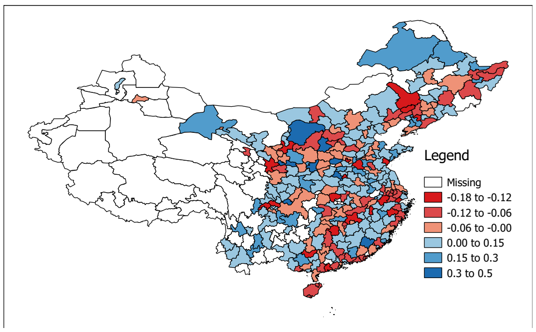


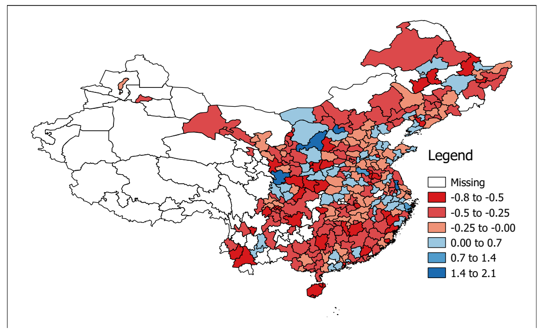
(a) Output Frictions,City-Level



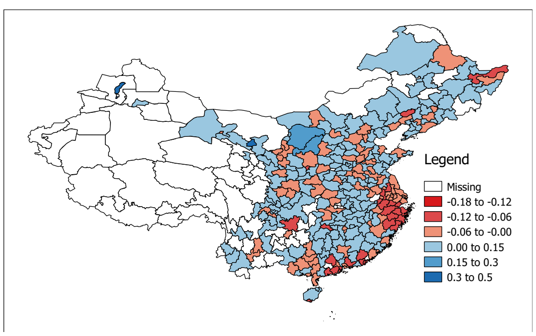
(b) Labor Frictions, City-Level



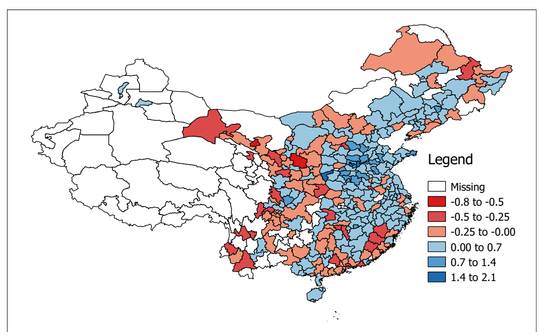
(c) Output Frictions, SOE



(d) Labor Frictions, SOE



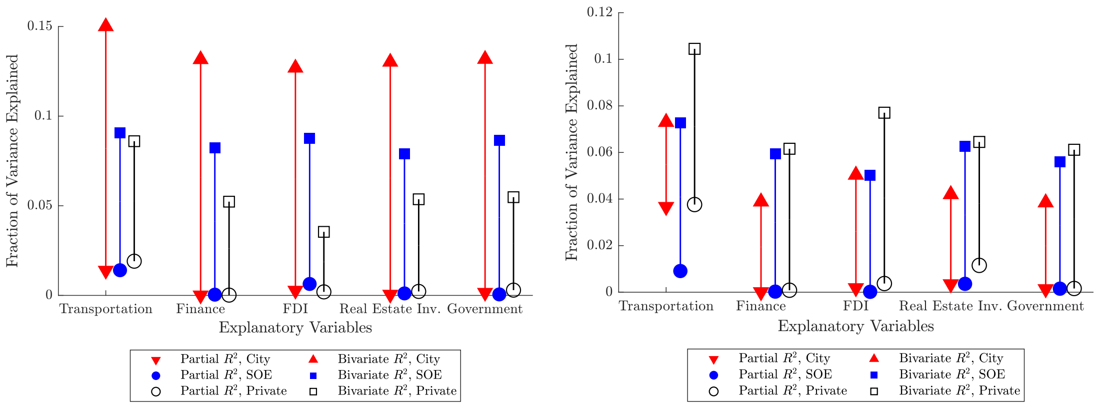
(e) Output Frictions, Private



(f) Labor Frictions, Private

Figure 1: Output and Labor Frictions over Space

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



(a) Output Frictions (b) Labor Frictions

Figure 2: Source of the Frictions

Notes: The figures plot the bi-variate and the partial R-squared of the estimated frictions into five groups of variables to explore the source of the spatial variations of the frictions. See the main text for the details of the decomposition.

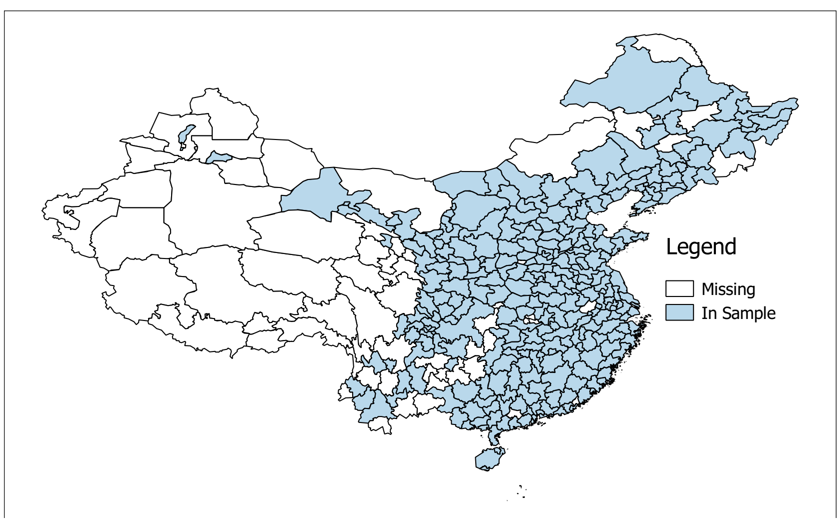
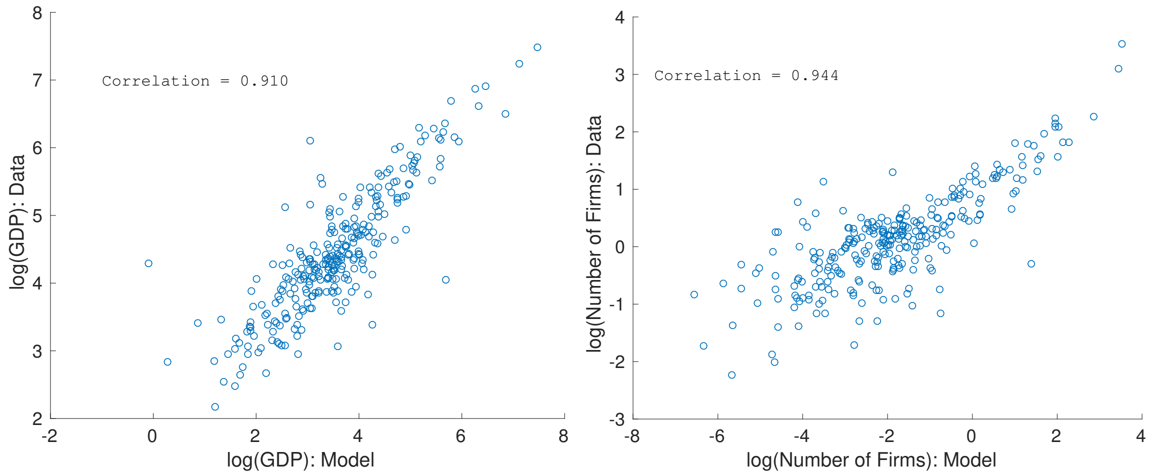


Figure 3: Prefecture-level Chinese Cities in Our Sample

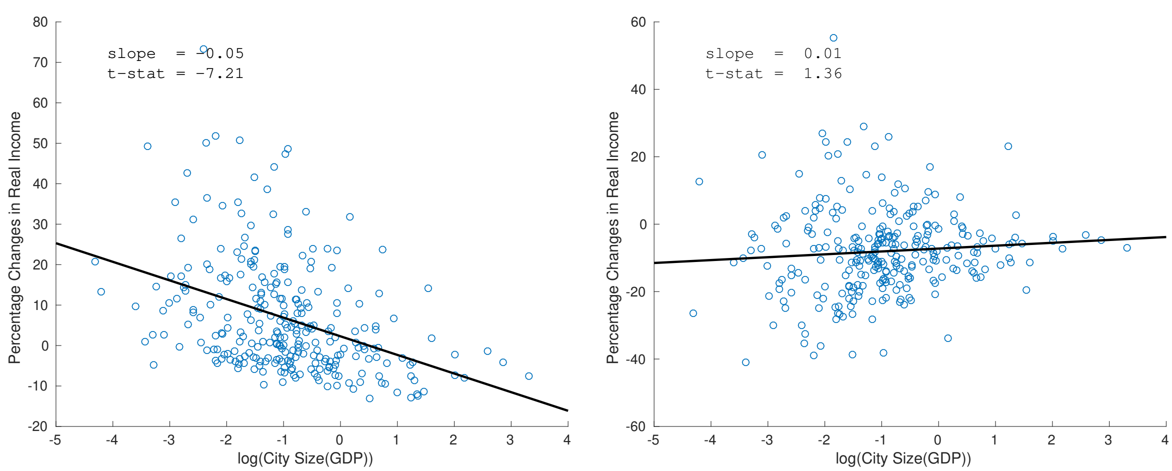
Notes: This graph plots the 279 prefecture-level cities in our sample. All the cities that are included both in the *Chinese Statistical Yearbooks* and the *2005 One-Percent Population Survey* are included in our sample.



(a) GDP (b) Number of Firms

Figure 4: Model Fit

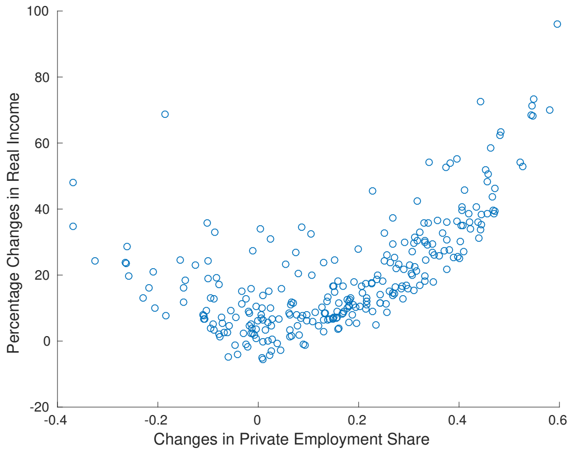
Notes: In the left panel, we plot the log of city-level GDP taken from *China City Statistical Yearbook* on the y-axis against the log of total disposable income predicted by the model on the x-axis. In the right panel, we plot the log of the number of firms taken from *the Second Economic Census* (2008) on the y-axis against the log of the number of operating firms predicted by the model on the x-axis.



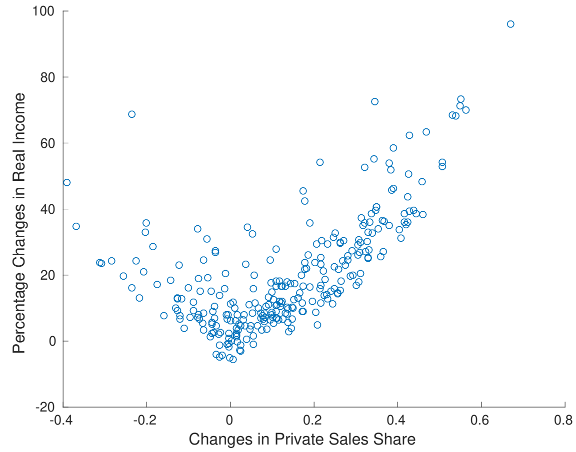
(a) Frictionless (b) Frictions in 1998

Figure 5: City size v.s. Changes in Real GDP, Frictionless

Notes: The figures plot the changes in real income between counterfactual and baseline simulation against the city size. We measure city size by the log of GDP. The left panel depicts the frictionless economy, and the right panel depicts the frictions estimated in 1998. Each dot represents a city.



(a) Employment



(b) Sales

Figure 6: Employment, Sales, and Gains in Real Income

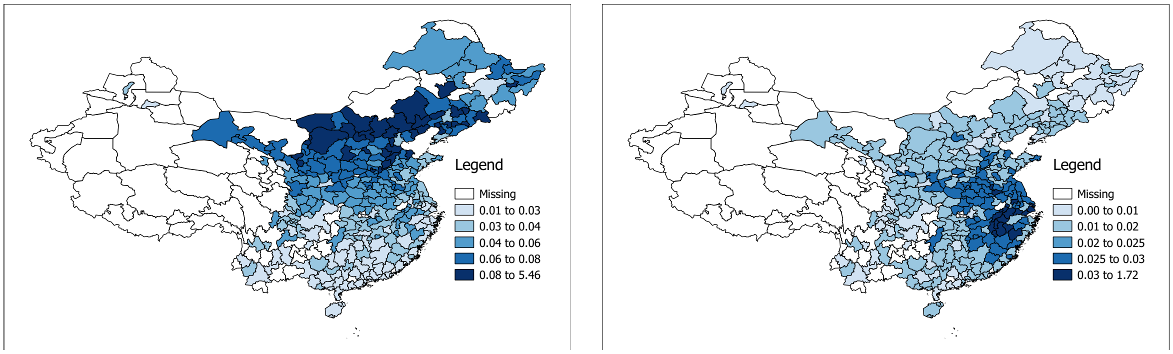
Notes: The figures plot the percentage changes in real disposable income against the changes in the employment share of private firms in the left panel, and against the changes in sales share of private firms from the benchmark to the frictionless case in the right panel. Each dot represents a city.

(a) Number of Entering Firms

(b) Ideal Price Index

Figure 7: Extensive Margin and Real Income

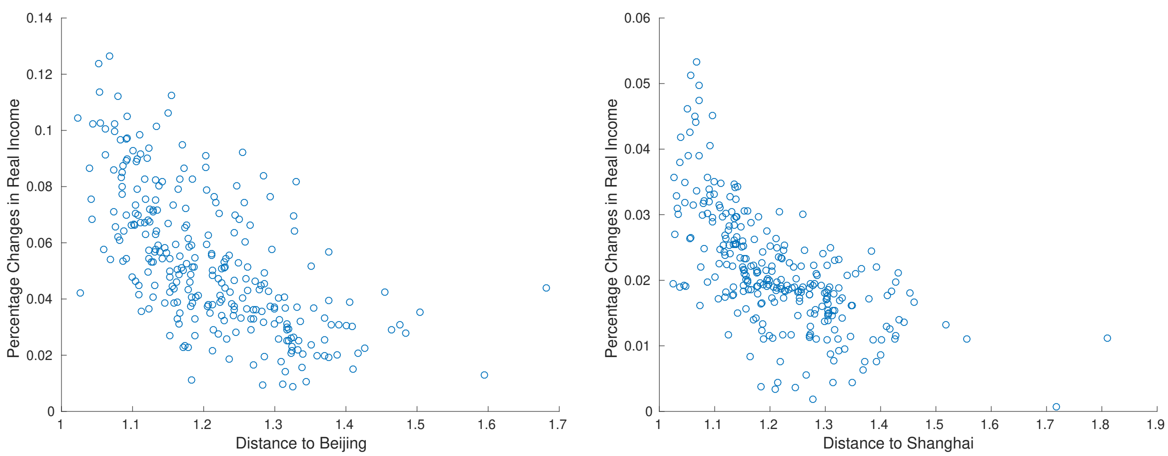
Notes: The left (right) panel plots the percentage changes in real income against the percentage changes in the number of operating firms (ideal price index) between the benchmark and the frictionless case. Each dot represents a city.



(a) Beijing (b) Shanghai

Figure 8: The welfare impacts from removing local frictions

Notes: The maps show the changes in real income from baseline results to the counter-factual simulations without the frictions in Beijing or Shanghai.



(a) Beijing (b) Shanghai

Figure 9: The welfare impacts from removing local frictions

Notes: The figures report the changes in real income between the benchmark and counterfactual economy against distances to the city whose frictions are adjusted. We exclude Beijing in panel (a) and Shanghai in panel(b) to avoid distorting the vertical scale. The distances are measured using the geographic costs matrix in Ma and Tang (2016).

Table 1: Summary Statistics, Firm Level Data, 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) Private 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 *Annual Surveys* in 2007. Total sales and value-added are in thousands RMB, and employment is in the unit of person.

Table 2: Summary Statistics, City Level Frictions

(a) Output Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
1998	0.044	0.103	-0.065	-0.025	0.027	0.091	0.162
1999	0.041	0.110	-0.068	-0.035	0.018	0.086	0.190
2000	0.028	0.100	-0.078	-0.031	0.015	0.066	0.134
2001	0.028	0.086	-0.067	-0.028	0.017	0.066	0.129
2002	0.023	0.080	-0.066	-0.024	0.011	0.057	0.126
2003	0.025	0.076	-0.055	-0.030	0.015	0.058	0.126
2004	0.013	0.067	-0.063	-0.032	0.008	0.048	0.096
2005	0.020	0.069	-0.060	-0.025	0.014	0.055	0.097
2006	0.027	0.075	-0.052	-0.015	0.018	0.056	0.106
2007	0.024	0.063	-0.056	-0.016	0.020	0.061	0.102
Total	0.027	0.085	-0.064	-0.026	0.016	0.063	0.126

(b) Labor Frictions

Year	Mean	Sd	P10	P25	Median	P75	P90
1998	0.085	0.310	-0.283	-0.134	0.066	0.255	0.533
1999	0.099	0.358	-0.297	-0.145	0.031	0.306	0.593
2000	0.077	0.317	-0.282	-0.154	0.039	0.246	0.554
2001	0.099	0.365	-0.273	-0.137	0.046	0.262	0.479
2002	0.078	0.311	-0.251	-0.133	0.038	0.249	0.439
2003	0.110	0.324	-0.243	-0.132	0.050	0.297	0.538
2004	0.019	0.253	-0.262	-0.152	-0.015	0.175	0.354
2005	0.040	0.259	-0.264	-0.138	-0.006	0.204	0.423
2006	0.034	0.295	-0.293	-0.178	-0.009	0.213	0.452
2007	0.078	0.327	-0.275	-0.155	0.006	0.277	0.500
Total	0.072	0.315	-0.272	-0.148	0.021	0.245	0.479

Notes: This table reports the city-level frictions estimated from the *Annual Surveys*. "Mean" is the simple average across all the cities within a given year, and "Sd" is the standard deviation. "P10","P25","P75","P90" refer to the respective percentile within the same year. See Section 3 for more details.

Table 3: Frictions over Space

(a) Population

	Abs(Output Frictions)					Abs(Labor Frictions)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln(Pop.)	-0.014***	-0.013***	-2.118	-0.013***	-0.022	-0.027***	-0.025**	-3.071	-0.025**	0.031
	(0.002)	(0.002)	(1.330)	(0.002)	(0.024)	(0.010)	(0.010)	(4.246)	(0.010)	(0.067)
Year		-0.003***	-0.008**				-0.003*	-0.011		
		(0.001)	(0.003)				(0.002)	(0.010)		
Ln(Pop.) × Year			0.001					0.002		
			(0.001)					(0.002)		
N	2700	2700	2700	2700	2698	2700	2700	2700	2700	2698
R-squared	0.027	0.044	0.045	0.045	0.399	0.008	0.010	0.009	0.016	0.339
Year FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
City FE	No	No	No	No	Yes	No	No	No	No	Yes

(b) GDP

	Abs(Output Frictions)					Abs(Labor Frictions)				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ln(GDP)	-0.009***	-0.007***	-0.982	-0.006**	0.006	-0.014**	-0.012	-5.163*	-0.013	0.018
	(0.002)	(0.002)	(0.804)	(0.002)	(0.006)	(0.006)	(0.008)	(2.847)	(0.008)	(0.015)
Year		-0.002**	-0.005**				-0.001	-0.015*		
		(0.001)	(0.002)				(0.002)	(0.009)		
Ln(GDP) × Year			0.000					0.003*		
			(0.000)					(0.001)		
N	2628	2628	2628	2628	2626	2628	2628	2628	2628	2626
R-squared	0.026	0.031	0.031	0.031	0.405	0.005	0.004	0.005	0.012	0.359
Year FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes
City FE	No	No	No	No	Yes	No	No	No	No	Yes

Notes: The standard errors clustered at the city level are reported in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The table reports regressions of city-level frictions against population and GDP between 1998 and 2007. The unit of observation is city-year. The data source for population and GDP is the city-level statistical yearbooks and population census, and the frictions are based on the estimation procedure outlined in Section 3.

Table 4: Frictions over Time

LHS = Abs(Frictions)	Output Frictions			Labor Frictions		
	(1)	(2)	(3)	(4)	(5)	(6)
Year	-0.003***			-0.004**		
	(0.001)			(0.002)		
Year=1999		0.002	0.002		0.028*	0.027*
		(0.005)	(0.005)		(0.015)	(0.015)
Year=2000		-0.008*	-0.008*		-0.001	-0.002
		(0.005)	(0.005)		(0.014)	(0.014)
Year=2001		-0.014***	-0.014***		0.017	0.017
		(0.004)	(0.004)		(0.017)	(0.016)
Year=2002		-0.020***	-0.020***		-0.009	-0.009
		(0.004)	(0.004)		(0.014)	(0.014)
Year=2003		-0.021***	-0.021***		0.011	0.011
		(0.004)	(0.004)		(0.015)	(0.015)
Year=2004		-0.027***	-0.026***		-0.052***	-0.054***
		(0.005)	(0.005)		(0.014)	(0.014)
Year=2005		-0.026***	-0.026***		-0.043***	-0.043***
		(0.005)	(0.005)		(0.014)	(0.014)
Year=2006		-0.024***	-0.024***		-0.017	-0.018
		(0.006)	(0.006)		(0.015)	(0.015)
Year=2007		-0.027***	-0.027***		0.003	0.002
		(0.005)	(0.005)		(0.016)	(0.016)
N	2700	2700	2698	2700	2700	2698
R-squared	0.022	0.023	0.399	0.003	0.009	0.339
Year FE	No	Yes	Yes	No	Yes	Yes
City FE	No	No	Yes	No	No	Yes

Notes: The standard errors clustered at the city level are reported in parentheses. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The table reports regressions of city-level frictions against a linear time trend or year dummies. The unit of observation is city-year. The frictions are based on the estimation procedure outlined in Section 3.

Table 5: Within-City Frictions

LHS = (SOE) - (Private)	Output Frictions			Labor Frictions		
	(1)	(2)	(3)	(4)	(5)	(6)
Constants	0.053***	22.350***		-0.287***	-12.106	
	(0.005)	(2.852)		(0.018)	(7.871)	
Ln(Pop.)		0.012*	-0.082*		-0.015	0.044
		(0.006)	(0.048)		(0.024)	(0.214)
Year		-0.011***			0.006	
		(0.001)			(0.004)	
Year=1999			-0.011			0.023
			(0.011)			(0.040)
Year=2000			-0.009			0.027
			(0.010)			(0.041)
Year=2001			0.001			-0.015
			(0.012)			(0.048)
Year=2002			0.000			0.014
			(0.013)			(0.053)
Year=2003			-0.003			0.042
			(0.015)			(0.060)
Year=2004			-0.045***			0.101*
			(0.016)			(0.061)
Year=2005			-0.071***			0.071
			(0.018)			(0.066)
Year=2006			-0.066***			0.052
			(0.019)			(0.074)
Year=2007			-0.048**			-0.020
			(0.020)			(0.080)
N	2700	2700	2698	2700	2700	2698
R-squared	0.000	0.044	0.315	0.000	0.001	0.291
City FE	No	No	Yes	No	No	Yes

Notes: The standard errors clustered at the city level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The table reports regressions of within-city differences between SOEs and private firms against population between 1998 and 2007. The unit of observation is city-year. The data source for population is the city-level statistical yearbooks and population census, and the frictions are based on the estimation procedure outlined in Section 3.

Table 6: Source of Frictions

	Output Friction			Labor Friction		
	(1) City	(2) SOE	(3) Private	(4) City	(5) SOE	(6) Private
Ln(Pop.)	-0.010**	-0.010	-0.006*	-0.010	-0.023	0.001
	(0.005)	(0.008)	(0.004)	(0.021)	(0.021)	(0.033)
SOE employment share	-0.072***	-0.170***	0.028**	0.046	-0.051	0.449***
	(0.022)	(0.036)	(0.014)	(0.070)	(0.072)	(0.153)
SOE sales share	0.124***	0.164***	-0.022*	-0.176***	-0.065	-0.500***
	(0.023)	(0.035)	(0.011)	(0.064)	(0.063)	(0.132)
	Location and Transportation					
Ln(centrality)	-0.131***	-0.183**	-0.117***	0.447***	-0.237*	0.736***
	(0.050)	(0.071)	(0.032)	(0.147)	(0.124)	(0.224)
Ln(paved road/pop.)	0.003	0.002	0.005*	0.058***	-0.028*	0.079***
	(0.005)	(0.006)	(0.003)	(0.016)	(0.014)	(0.022)
Ln(passenger volume)	0.002	-0.005	-0.000	-0.021	-0.023*	-0.012
	(0.003)	(0.005)	(0.003)	(0.013)	(0.013)	(0.020)
Ln(freight volume)	0.002	-0.005	0.000	-0.007	0.008	-0.014
	(0.003)	(0.005)	(0.003)	(0.012)	(0.012)	(0.016)
	Finance					
Ln(savings)	0.001	-0.004	0.001	0.004	-0.007	0.016
	(0.003)	(0.007)	(0.002)	(0.011)	(0.011)	(0.017)
	FDI					
Ln(FDI, contracted)	-0.003*	-0.005*	-0.001	-0.009	-0.001	-0.015
	(0.002)	(0.003)	(0.001)	(0.006)	(0.006)	(0.009)
Ln(FDI, utilized)	0.002	0.008**	-0.001	0.006	-0.002	0.017*
	(0.002)	(0.003)	(0.001)	(0.006)	(0.006)	(0.009)
	Real Estate Investment					
Ln(real estate inv.)	-0.001	-0.003	0.002	-0.016*	-0.013*	-0.041***
	(0.002)	(0.004)	(0.002)	(0.009)	(0.008)	(0.015)
Ln(residential inv.)	-0.001	0.005*	-0.003**	-0.004	-0.011	-0.007
	(0.002)	(0.003)	(0.002)	(0.008)	(0.010)	(0.012)
	Local Government					
Ln(local gov. budget)	0.001	0.002	-0.001	0.013	0.014	0.021
	(0.004)	(0.008)	(0.004)	(0.015)	(0.013)	(0.024)
Local gov. surplus	0.011	-0.013	0.014	-0.044	0.022	-0.062
	(0.012)	(0.019)	(0.009)	(0.038)	(0.034)	(0.051)
Constant	0.046	0.166***	0.073**	0.585***	0.790***	0.600***
	(0.039)	(0.054)	(0.029)	(0.133)	(0.149)	(0.185)
N	1985	1985	1985	1985	1985	1985
R-Squared	0.133	0.085	0.050	0.083	0.063	0.120
FE	year	year	year	year	year	year

Notes: The standard errors clustered at the city level are reported in parentheses. * p<0.10, ** p<0.05, *** p<0.01. The table reports regressions of frictions against a broad set of city characteristics. The unit of observation is city-year. The data source for population is the city-level statistical yearbooks and population census, and the frictions are based on the estimation procedure outlined in Section 3.

Table 7: Benchmark Parameterizations

Para.	Targets	Value
β	Labor share	0.30
θ	Pareto index in productivity distribution	5.3
ε	Elasticity of substitution	6.0
f_e	Number of firms, Shanghai	0.71
$\bar{\tau}$	Internal trade/GDP ratio	2.19
ζ	Entrants/operating firm ratio	0.03
$\{L_j\}$	Population distribution	
$\{\lambda_j\}$	Provincial employment share among SOEs	

Notes: The calibration target for β comes from the *Annual Survey* for 491 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.

Table 8: SOE employment share by province

Province	Value (%)	Province	Value (%)
Anhui	34.99	Jiangsu	6.40
Beijing	37.75	Jiangxi	24.24
Chongqing	31.26	Jilin	41.47
Fujian	6.34	Liaoning	31.68
Gansu	61.62	Ningxia	49.94
Guangdong	5.21	Qinghai	60.85
Guangxi	30.03	Shaanxi	59.27
Guizhou	53.94	Shandong	17.03
Hainan	29.74	Shanghai	16.45
Hebei	29.32	Shanxi	53.30
Heilongjiang	56.95	Sichuan	29.27
Henan	28.54	Tianjin	29.45
Hubei	30.73	Xingjiang	67.88
Hunan	26.30	Yunnan	39.38
Inner Mogolia	38.99	Zhejiang	3.99

Notes: This table reports the employment share of SOE firms in each province. We directly use the employment share for all the prefecture-level cities within the same province. The data source is *the Second Economic Census* in 2008.

Table 9: Aggregate Results

	Benchmark	Frictionless	No Spatial Diff.	Beijing	Shanghai	No Within-City Diff.	No Entry	1998
Real Income	255.37	282.27	269.90	256.40	255.87	273.03	269.53	243.10
	Size of Distortions							
Aggregate	-0.059	0.000	-0.070	-0.055	-0.066	0.028	0.000	-0.018
Output, SOE	0.020	0.000	0.066	0.014	0.017	0.015	0.000	0.063
Output, Private	-0.024	0.000	-0.010	-0.020	-0.023	0.000	0.000	-0.012
Labor, SOE	-0.076	0.000	-0.133	-0.072	-0.076	0.001	0.000	-0.086
Labor, Private	0.021	0.000	0.007	0.023	0.015	0.011	0.000	0.017
	Employment Share							
SOE	0.472	0.346	0.852	0.475	0.473	0.352	0.347	0.780
Private	0.527	0.653	0.147	0.525	0.526	0.647	0.650	0.220
	Number of Operating Firms							
Total	267.29	273.51	257.56	268.97	268.28	272.05	267.29	248.43
SOE	59.02	57.97	216.33	63.74	60.96	53.71	59.02	202.81
Private	208.26	215.54	41.23	205.23	207.32	218.34	208.26	45.62
	Inequality Measures							
Most Improved City(%)	-	95.934	87.337	5.460	1.715	69.231	58.562	66.738
Least Improved City(%)	-	-5.565	-9.704	0.009	0.001	-15.479	-4.582	-61.496
Coef. of variation	2.519	2.384	2.384	2.536	2.535	2.410	2.426	2.602
SD(LN(Real Income))	1.204	1.155	1.155	1.204	1.204	1.172	1.193	1.198
Real Income, P(90)/P(50)	5.036	4.671	4.672	5.036	5.036	4.785	5.025	4.963
Real Income, P(90)/P(10)	21.088	18.329	18.330	21.083	21.089	18.841	20.757	21.421
Real Income, P(50)/P(10)	4.188	3.924	3.924	4.186	4.188	3.937	4.131	4.316
Trade Openness	0.623	0.617	0.617	0.623	0.623	0.620	0.616	0.625

Notes: This table reports the aggregate impacts of our seven counter-factual analyses. Column 2 eliminates all the frictions. Column 3 equalizes each type of frictions across all the cities to their respective weighted average. Column 4 and 5 eliminate frictions in Beijing and Shanghai, respectively. Column 6 assumes equal frictions within each city. Column 7 shuts down the channel of firm entry and exit. Column 8 reverts the frictions to their levels in 1998. We report levels in real income, size of distortions, the employment share, the number of operating firms, trade openness and income inequality.

Table 10: The Role of Location and Transportation

	Benchmark	Lower Costs	Lower Costs + Adj. Fric	Lower Costs + Adj. Output Fric	Lower Costs + Adj. Labor Fric
Real Income	255.37	259.10	259.13	259.11	259.12
			Size of Distortions		
Aggregate	-0.059	-0.049	-0.048	-0.049	-0.049
Output, SOE	0.020	0.008	0.008	0.008	0.008
Output, Private	-0.024	-0.012	-0.012	-0.012	-0.012
Labor, SOE	-0.076	-0.065	-0.065	-0.065	-0.065
Labor, Private	0.021	0.021	0.021	0.021	0.021
			Employment Share		
SOE	0.379	0.341	0.341	0.341	0.341
Private	0.621	0.660	0.660	0.659	0.660
			Number of Operating Firms		
Total	267.29	265.87	265.89	265.86	265.92
SOE	59.02	60.55	60.55	60.56	60.55
Private	208.26	205.32	205.34	205.30	205.38
			Inequality Measures		
Most Improved City(%)	-	23.313	23.354	23.351	23.322
Least Improved City(%)	-	-49.021	-48.985	-48.989	-49.020
Coef. of variation	2.519	2.518	2.518	2.518	2.518
SD(LN(Real Income))	1.204	1.210	1.209	1.210	1.210
Real Income, P(90)/P(50)	5.036	5.050	5.045	5.050	5.045
Real Income, P(90)/P(10)	21.088	20.151	20.142	20.150	20.145
Real Income, P(50)/P(10)	4.188	3.990	3.992	3.990	3.993
Trade Openness	0.623	0.635	0.635	0.635	0.635

Notes: This table compares the benchmark results with an economy where we uniformly lower the benchmark ice-berg trade costs across all the city pairs by 1-percent. The last column of the table reports the results for an economy where we not only lower the ice-berg trade costs but also adjust the output and labor frictions for both types of firms according to estimation results in Table 6.

Appendix

A Solving the Model

A.1 Autarky Equilibrium

In the autarky scenario, each individual firm only serves its own home market. The expected profit at the entry stage is:

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

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_j in city j. Thus, free entry condition in city j is:

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

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

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

Alternatively, the price index can be expressed into:

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

Equalizing the above two expressions for price index 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

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

The 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 give rise to the solution of X_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 operating firm in city j is:

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

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

When we also include the labor demand at the entry stage, the labor market clearing condition in each city is thus:

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

A.2 Trade Equilibrium

In each city, we need to solve a series of $\{w_j, M_j, P_j, X_j\}$. Since firm productivity follows a type-1 Pareto distribution, the ideal price index in city i can thus be expressed as:

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

where a_{ij}^S and a_{ij}^N can further be obtained from the following zero profit conditions

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

Therefore, substituting the expression of a_{ij}^d into the ideal price index gives:

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

The free entry condition in city j is

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

The total expenditure of city j, X_j, is the final spending by the consumers, plus expenditure on composite varieties:

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

Denote the disposable income in city j as Y_j. Without any distortions, the disposable income is simply w_jL_j. However with both distortions:

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

where L_{ij}^d is the labor demand, including those used to cover both the variable and the fixed costs of production for selling to market i, and X_{ij}^d is the sales revenue generated from city i. Note that when $\tau_{\{\cdot\}} > 0$, it generates a positive tax revenue, and then the local government repays back the tax revenue 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 on workers to balance the budget.

We obtain the labor demand in the trade equilibrium by summing up the labor demand from all the operating firms as well as those demanded at the entry stage. The total sales from city i to city j by types of firm d is:

$$\begin{aligned} X_{ji}^d &= I_i^d \int_0^{a_{ji}^d} \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon-1} \frac{a \cdot t_{ji} c_i^d}{1-\tau_{y,i}^d} \right)^{1-\varepsilon} dG(a) \\ &= I_i^d \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon-1} \frac{t_{ji} c_i^d}{1-\tau_{y,i}^d} \right)^{1-\varepsilon} \frac{\mu^\theta \theta}{\theta-(\varepsilon-1)} \left(a_{ji}^d\right)^{\theta-(\varepsilon-1)}. \end{aligned}$$

The number of input bundles required to generate the sales above is:

$$d(c_{ji}^d) = I_i^d \int_0^{a_{ji}^d} \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{a \cdot t_{ji} c_i^d}{1 - \tau_{y,i}^d} \right)^{-\varepsilon} a dG(a)$$
$$= I_i^d \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{t_{ji} c_i^d}{1 - \tau_{y,i}^d} \right)^{-\varepsilon} \frac{\mu^\theta \theta}{\theta - (\varepsilon - 1)} \left(a_{ji}^d \right)^{\theta - (\varepsilon - 1)}.$$

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

$$l_i^d = \left[\frac{P_i}{(1 + \tau_{l,i}^d) w_i} \right]^{1-\beta} \left(\frac{\beta}{1 - \beta} \right)^{1-\beta}$$
$$= \frac{\beta c_i^d}{(1 + \tau_{l,i}^d) w_i},$$

and thus the labor demand to generate X_{ji} is:

$$l_i^d \cdot d(c_{ji}^d) = \frac{\beta c_i^d}{(1 + \tau_{l,i}^d) w_i} \cdot \left\{ I_i^d \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{t_{ji} c_i^d}{1 - \tau_{y,i}^d} \right)^{-\varepsilon} \frac{\mu^\theta \theta}{\theta - (\varepsilon - 1)} \left(a_{ji}^d \right)^{\theta - (\varepsilon - 1)} \right\}.$$

Firms also need to purchase input bundles to pay for the fixed operating costs. The total demand for input bundles in city i in order to cover the operating costs of serving city j is:

$$d_{f,ji} = f_{ji} I_i^d \int_0^{a_{ji}^d} dG(a) = f_{ji} I_i^d \cdot G(a_{ji}^d)$$
$$= f_{ji} I_i^s \mu^\theta \left(a_{ji}^d \right)^\theta$$

As a result, the total labor demand incurred in city i for serving city j is the sum of both variable and fixed costs of production,:

$$L_{ji}^d = l_i^d \cdot (d(c_{ji}^d) + d_{f,ji})$$
$$= \frac{\beta c_i^d}{(1 + \tau_{l,i}^d) w_i} \cdot \left\{ I_i^d \frac{X_j}{P_j^{1-\varepsilon}} \left(\frac{\varepsilon}{\varepsilon - 1} \frac{t_{ji} c_i^d}{1 - \tau_{y,i}^d} \right)^{-\varepsilon} \frac{\mu^\theta \theta}{\theta - (\varepsilon - 1)} \left(a_{ji}^d \right)^{\theta - (\varepsilon - 1)} + f_{ji} I_i^d \mu^\theta \left(a_{ji}^d \right)^\theta \right\}.$$

The total labor demand in city i is thus the sum of labor demand by all destinations and types of firms, as well as the labor incurred to cover the entry costs measured as un-distorted input bundles:

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

Finally, the labor market clearing condition in city i is given as:

$$L_{d,i} = L_i.$$

The equation above enables us to pin down the equilibrium wage rate in city i.

B Additional Quantitative Results

B.1 Decomposition of Frictions in 2007

The upper panel in Table B.1 studies the impacts of shutting down individual types of frictions. Shutting down labor frictions among private firms in all the cities leads to the highest gain in aggregate welfare: $262.86/255.37 - 1 \approx 2.9$ percent, or $2.9/10.5 \approx 27.6$ percent of the aggregate gain in the frictionless case. The mechanism behind the gain is similar to what we have documented before: when labor taxes are removed from private firms, the treatment to labor in SOEs becomes less favorable, workers are reallocated to the more productive private sectors, leading more firms to enter into the private sectors, which results in larger aggregate welfare gain. Removing the output frictions from the private sectors leads to a similar but smaller scale of labor re-allocation, and thus smaller gains in aggregate welfare: $258.47/255.37 - 1 \approx 1.2$ percent, or $1.2/10.5 \approx 11.4$ percent of the overall gain from the frictionless economy.

Removing labor frictions from the SOEs also leads to a welfare gain at 0.3 percent. Removing the labor subsidies from SOEs lowers the employment share and the number of operating firms in the SOE sector. On the other hand, removing output frictions from the SOEs will lead to a welfare loss of 1.2 percent. Removing the positive output frictions from SOEs effectively makes less productive SOEs able to survive, and thus the sector expands at the cost of lower aggregate income. From the perspective of spatial inequality, removing the labor frictions from private firms also leads to the highest reduction in inequality: the coefficient of variation declines from 2.52 to 2.40—a 4.8 percent decrease—almost on par with the effects from the removal of all the frictions. This is probably because the private sectors in the poorest cities of the inland provinces suffer significantly higher labor frictions, and the resources and production are organized much more efficiently once those frictions are removed.

The lower panel of Table B.1 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: $270.42/255.37 - 1 \approx 5.9$ percent, or $5.9/10.5 \approx 56.2$ percent of the overall gain from the frictionless economy; the removal of the output frictions lead to $259.55/255.37 - 1 \approx 1.6$ percent, or $1.6/10.5 \approx 15.2$ percent of the overall gain. The dominant role of labor frictions is not surprising: the size of the labor frictions is 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 private firms leads to higher welfare gain than that among the SOEs. This is again, mainly due to the labor-reallocation effects: removing labor frictions in private firms releases workers from SOEs to the private sectors.

B.2 Sensitivity Analysis

In the baseline model, we estimated β, the labor share in the production function, as the ratio between the total wage bill and total production expenses. As β is a crucial parameter in identifying the labor frictions, we provide an alternative way of estimation based upon the ratio between the total wage bill and the sale revenue. We report the results for benchmark, frictionless economy and the economy with no spatial differences using this alternative measure of labor share in Table B.2 as a robustness check. The magnitude of the changes in all the aggregate indicators remains qualitatively unchanged.

Table B.1: Decomposition of Frictions

	Benchmark	SOE Output	Private Output	SOE Labor	Private Labor
Real Income	255.37	252.31	258.47	256.01	262.86
	Size of Distortions				
Aggregate	-0.059	0.008	0.065	0.102	-0.004
Output, SOE	0.020	0.000	0.034	0.031	0.029
Output, Private	-0.024	0.001	0.000	0.007	0.011
Labor, SOE	-0.076	-0.057	-0.043	0.000	-0.045
Labor, Private	0.021	0.064	0.073	0.064	0.000
	Employment Share				
SOE	0.379	0.437	0.362	0.358	0.293
Private	0.621	0.563	0.637	0.641	0.707
	Number of Operating Firms				
Total	267.29	263.89	256.25	260.05	263.62
SOE	59.02	82.56	66.65	59.89	57.80
Private	208.26	181.33	189.60	200.16	205.83
	Inequality Measures				
Most Improved City(%)	-	52.619	51.906	55.292	50.504
Least Improved City(%)	-	-39.384	-25.685	-26.808	-24.253
Coef. of variation	2.519	2.490	2.489	2.492	2.401
SD(LN(Real Income))	1.204	1.196	1.184	1.176	1.199
Trade Openness	0.623	0.622	0.620	0.621	0.623

	Benchmark	Output Friction	Labor Friction	SOE	Private
Real Income	255.37	259.55	270.42	259.27	269.31
	Size of Distortions				
Aggregate	-0.059	0.013	0.039	0.063	-0.017
Output, SOE	0.020	0.000	0.024	0.000	0.027
Output, Private	-0.024	0.000	0.015	0.004	0.000
Labor, SOE	-0.076	-0.056	0.000	0.000	-0.044
Labor, Private	0.021	0.069	0.000	0.059	0.000
	Employment Share				
SOE	0.379	0.406	0.242	0.403	0.262
Private	0.621	0.594	0.758	0.596	0.738
	Number of Operating Firms				
Total	267.29	262.33	267.12	267.04	263.01
SOE	59.02	80.92	48.26	73.26	55.67
Private	208.26	181.41	218.86	193.77	207.34
	Inequality Measures				
Most Improved City(%)	-	59.033	76.961	57.252	59.336
Least Improved City(%)	-	-35.314	-8.203	-23.876	-19.846
Coef. of variation	2.519	2.489	2.386	2.507	2.407
SD(LN(Real Income))	1.204	1.181	1.176	1.168	1.183
Trade Openness	0.623	0.619	0.621	0.620	0.620

Notes: The two tables report counter-factual analysis similarly to those reported in Table 9. The upper panel removes labor or output frictions for each type of firms separately, and the lower panel removes the frictions by groups.

Table B.2: Sensitivity Results

	Benchmark	Frictionless	No Spatial Diff.
Real Income	248.31	282.27	260.90
	Size of Distortions		
Aggregate	-0.225	0.000	-0.147
Output, SOE	0.031	0.000	0.026
Output, Private	-0.004	0.000	0.040
Labor, SOE	-0.150	0.000	-0.054
Labor, Private	-0.102	0.000	-0.159
	Employment Share		
SOE	0.396	0.260	0.260
Private	0.604	0.740	0.740
	Number of Operating Firms		
Total	260.32	273.51	255.46
SOE	58.76	57.97	50.45
Private	201.56	215.54	205.01
	Inequality Measures		
Most Improved City(%)	-	100.724	89.890
Least Improved City(%)	-	-3.984	-18.574
Coef. of variation	2.525	2.384	2.359
SD(LN(Real Income))	1.210	1.155	1.178
Real Income, P(90)/P(50)	5.055	4.671	4.782
Real Income, P(90)/P(10)	21.184	18.329	18.971
Real Income, P(50)/P(10)	4.191	3.924	3.967
Trade Openness	0.624	0.617	0.620

Notes: This table reports the results from our benchmark economy and various counter-factual cases using an alternative measure of labor share, which is estimated as the ratio between the total wage bill and the sales revenue.