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VAT RATE DISPERSION AND TFP LOSS IN CHINA'S MANUFACTURING SECTOR

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VAT Rate Dispersion and TFP Loss in China's Manufacturing Sector

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Abstract

The paper studies dispersion in the effective VAT rate, a directly measurable distortion, across manufacturing firms in China and assesses its impact on aggregate production efficiency through mis-allocation from 2000 to 2007. Using a structural model based on Hsieh and Klenow (2009), I find that a revenue-neutral tax reform which eliminates the dispersion in VAT rates alone produces a gain in aggregate TFP in the order of 7.9% of GDP on average in the period from 2000 to 2007.

JEL Classification: D24, H21, H25, O47

Keywords: VAT, mis-allocation, TFP, China

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1 Introduction

Many studies in development accounting confirm that it is the total factor productivity (TFP), rather than production factors, that mainly drives the cross-country income disparity (Klenow and Rodriguez-Clare, 1997; Prescott, 1998; Hall and Jones, 1999; Caselli, 2005; Hsieh and Klenow, 2010).

Over the past decade, an increasing strand of literature has been emphasizing the role of resource mis-allocation, which claims that the low aggregate TFP in poor countries could be neither mainly caused by low production efficiency of some production units, nor by lack of capital or other inputs, but by the fact that the inputs are not efficiently allocated among production units in these countries. Therefore, the aggregate production efficiency can increase by re-allocating a total given amount of production inputs within a poor economy (Hsieh and Klenow, 2009; Rogerson and Rustuccia, 2008; Bartelsman, Haltiwanger, and Scarpetta, 2013).

The idea of mis-allocation is not only theoretically fascinating, but also quantitatively important. In an influential study, Hsieh and Klenow (2009) state that the mis-allocation leads to enormous aggregate TFP loss. Using the micro level data in the U.S., China, and Indian, they find TFP would increase by 30 to 50 percent in China and 40 to 60 percent in India if the dispersion of the tax rates were reduced to the levels found in the United States.¹

Despite the quantitative evidence provided on the importance of mis-allocation, the findings of Hsieh and Klenow (2009), as well as other studies using indirect approaches,² are subject to some criticisms.³ Firstly, sources of distortions in these studies are not clear. Because all taxes and wedges are embodied only in a single tax (wedge) which is backed out from a quantitative model, it is hard to assess the importance of each tax (wedge) and to offer specific policy suggestions aimed to mitigate a particular distortion. Second, mis-calculation can be made due to model mis-specification. This is because an indirect measure of distortion may change, sometimes in a very sensitive way, with the functional

¹Alternatively, Bartelsman, Haltiwanger, and Scarpetta (2013) propose that the covariance between productivity and size is a good indicator for distortion. A bigger (within-industry) dispersion in distortion generally implies smaller size-productivity covariance and translates into poor economic performance.

²Restuccia and Rogerson (2013) classify existing studies on mis-allocation into direct approach and indirect approach. The former picks one (or more) directly measurable distortion(s) and assess its (their) impact on aggregate TFP, while the latter indirectly obtain distortionary wedges (taxes) from theoretical models.

³To avoid over-statements on the role of mis-allocation due to “measurement error and factors omitted from the model (such as adjustment costs and mark-up variation) that generate gaps in marginal products even in a comparatively undistorted country such as the United States”, Hsieh and Klenow (2009) take two measures. First, they use the U. S. as a benchmark and measure “how much TFP in China and India could increase if capital and labour were reallocated to equalize marginal products across plants within each four-digit sector to the extent observed in the United States”. Second, they show that the distortions implied by their model are really associated with firm ownership and economic reform in China and India, suggesting that the distortions should not be driven mainly by measurement errors.

form and parameters' value. One possible way to overcome the above criticisms is to focus on a particular directly measurable tax which is independent of model specification and to discover its quantitative importance in mis-allocation.

This paper attempts to contribute in this regard by assessing the TFP gain of China's manufacturing sector from eliminating dispersion in effective VAT rates across firms during the period 2000 - 2007. To this end, I use the Annual Survey of Industrial Production of China and propose an approach based on a multi-tier monopolistic competition model of Hsieh and Klenow (2009), and with an augmented human capital measurement from Chinese mini population census. The results suggest huge efficiency gain – a revenue-neutral reform which eliminates the dispersion in VAT rates improves aggregate TFP in the order of 7.9% of GDP on average in the sample period.⁴

Advantages of focusing on VAT in China are obvious. First, the effective VAT rate is directly measurable. It is irrelevant to model specification and independent of model parameters' value. Second, given the relatively uniform tax codes of VAT and the available firm level data, the measurement of the effective VAT rate is relatively neat and clean compared to many other distortions that one can think of.⁵ Third, VAT rate dispersion is large in China, either due to differential statutory tax rates or discriminative tax enforcement across firms, and that allows us to easily capture its impact on TFP loss.⁶ Lastly, welfare gain from any feasible VAT reform could be gigantic. VAT is the most important tax in China and contributes about one-third of the total tax revenue for the whole country. It is also very popular in the rest of the world. So far more than one-hundred countries have adopted VAT.

Empirically, the VAT rate dispersion across China's manufacturing firms is not only large in magnitude, but also persistent, coming from within four-digit industry and almost uncorrelated with some important firm's characteristics.⁷ These distributional features translate into significant and persistent efficiency loss. I find that the VAT rate dispersion mainly comes from firms' time-persistent factors such as geographic location, ownership

⁴Oberfield (2013) also adopts the framework of Hsieh and Klenow (2009) and quantifies the contribution of resource misallocation to TFP fall in Chile.

⁵Firms in the Annual Survey of Industrial Production are quite formal and under strict supervision of both tax administration and bureau of statistics. The mis-allocation in this paper, therefore, is absent from mis-allocation due to informality as highlighted by studies such as Leal Ordóñez (2014), D'Erasmus and Moscoso Boedo (2012).

⁶In this paper, I focus only on the VAT in China and ignore the efficiency loss caused by other taxes such as sales tax, capital gains tax, personal income tax, resource tax, and others. There are several reasons for doing so. First, it is the VAT, rather than the corporate income tax, that is particularly relevant to the distortion on product in the theoretical model that we use. Second, VAT is the most important tax in China. It accounts for nearly one-third of the government total tax revenue, and therefore has gigantic welfare implication. Third, effective VAT rate at the firm level is available in China's firm survey.

⁷This is a bit different from two other studies respectively by Restuccia and Rogerson (2008) and Guner, Ventura, Xu (2008). The first one suggests that the TFP loss is bigger if distortions and firm productivity are positively correlated. And the second one shows that the "size-dependent policy" could lead to considerable reductions in productivity.

and internal organization. These findings may provide an alternative answer to the question, raised by Moll and Banerjee (2010) and by some other cross-country development studies, of why distortions persist.

Of course, in addition to the effective VAT rate as highlighted in this paper, there are many other sources of distortions leading to mis-allocation and TFP loss. The paper only makes a complementary contribution to a huge literature in this regard. As existing studies suggest, the mis-allocation can be due to many causes such as information (David, Hopenhayan, and Venkateswaran, 2015), credit constraints and distortions in capital markets (Erosa, 2001; Amaral and Quintin, 2010; Buera et al. 2011; Banerjee and Moll, 2010; Kalemli-Ozcan and Sorensen, 2012; Gilchrist et al., 2013; Caggese, Vicente Cuñat, 2013), distortions in labour market (Hopenhayn and Rogerson, 1993; Lagos, 2006), trade barriers (Alcala and Ciccone, 2004; Pavcnik, 2002; Lileeva and Trefler, 2010; Waugh, 2010; Tombe, 2012; Epifani and Gancia, 2011; Bond et al., 2013; Eslava et al., 2013), informality (Leal Ordóñez, 2014; D’Erasmus and Moscoso Boedo, 2012), managerial investments (Bhattacharya et al., 2013), selection effect on firm productivity (Gabler and Poschke, 2013), or related to stage of development (Ziebarth, 2013).⁸ With a focus on TFP losses in China’s non-agricultural economy, Brandt et al. (2013) find that mis-allocation of capital between state and non-state sectors within provinces can largely account for the increasing TFP losses in China after mid-1990s.

Although the paper is based on Hsieh and Klenow (2009)’s static monopolistic competition model, given the measurable nature of the effective VAT rate, a study of its impact on TFP loss can be also built upon other frameworks such as decreasing return model of Rogerson and Rustuccia (2008), as well as in various dynamic setting *a la* Hopenhayn (1992) or Olley and Pakes (1996).⁹

The paper as well enriches our understanding of taxation and efficiency loss in public finance literature. Traditionally, the efficiency loss can be captured by the Harberger triangle. Following the seminar work of Harberger (1964a, b), a wide array of tax-induced distortions have been investigated to assess their welfare impact, including those to labour supply (Browning, 1975), saving (Feldstein, 1978), corporate taxation (Shoven, 1976), and the consumption of goods (King, 1983). The magnitudes of the welfare loss, nevertheless, are still ambiguous in these studies, ranging from as low as 2.5% of the tax revenue (Harberger, 1964b) to the stunning 200% (Feldstein, 1999).

The finding in this paper echoes an efficiency-enhancing VAT reform recently advocated by Mirrlees *et al.* (2011). VAT in practice leads to welfare loss for various reasons,

⁸However, Midrigan and Xu (2014) use the plant level data in Korean, China, and Colombia and find that financial frictions lead to fairly small losses through misallocation, but potentially sizable losses through inefficiently low levels of entry and technology adoption.

⁹There are also other dynamic settings in recent literature on mis-allocation. For example, Asker et al. (2012) investigate the role of dynamic production inputs and their associated adjustment costs in shaping the dispersion of TFP and static measures of capital mis-allocation within a country.

including exemption of certain sectors out of the VAT system, differential tax rates, zero rating, and so on. Theoretically, the nature of mis-allocation implies a desirable feature of tax reforms aimed to reduce tax rates dispersion. Such reforms can improve efficiency but do not necessarily involve changes in total tax revenue. In empirics, Mirrlees *et al.* (2011, Chapter 9) finds that the government tax revenue could increase by three billion pounds by eliminating the differential tax rates, while still maintaining the welfare level of the UK family. Zee (2006) finds that the exemption of financial services out of the VAT system leads to a efficiency loss amounting to about 30% of the GDP of the UK. Piggott and Whalley (2001) analyse the efficiency loss caused by the enlarging of the informal sector after the VAT expansion in Canada.

Before moving on, I draw figure 1.1 to give readers a glimpse at the distribution of the effective VAT rate across China's manufacturing firms in 2005. In the figure, the effective VAT rate is defined as the ratio of payable VAT to the value-added of a firm. Although the standard statutory tax rate is 17%, the effective tax rate varies enormously, with a standard deviation of 11% around the mean 10%. Majority of firms pay an effective tax rate that is lower than the statutory level.¹⁰

The rest of the paper is organized as follows. Section 2 introduces a toy model that explains the underlying mechanism of misallocation caused by dispersion in effective VAT rate across firms. Section 3 briefly introduces the institutional background of VAT in China. Section 4 presents a theoretical framework that relates tax rate dispersion to aggregate TFP loss. Section 5 summarizes the data used in this paper. Section 6 reports the results and main findings. Several robustness checks are conducted in Section 7, and Section 8 concludes.

2 Conceptual Framework

To understand the working mechanism of Hsieh and Klenow (2009), let us first consider a model economy consisting of two monopolistic competitive firms with one production factor (L units in total). The output Y is assumed to be produced with constant-return-to-scale technology: $Y_i = A_i L_i$, $i = 1, 2$, where A is the physical productivity (TFP). The monopolistic competition between two firms is featured with the output aggregator in Dixit-Stiglitz fashion: $Y = \left(Y_1^{\frac{\sigma-1}{\sigma}} + Y_2^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$, where σ is the elasticity of substitution, and it also reflects the degree of competition between firms. The GDP of this economy is aggregated over the value-added of all firms: $PY = P_1 Y_1 + P_2 Y_2$, where the final output

¹⁰It is a bit striking that the effective VAT rate in Figure 1.1 does not cluster around the standard statutory tax rate 17%. Apart from the statutory reasons such as differential tax rates and export tax refund, that is actually a vivid indication of poor VAT administration in China. Empirical studies suggest that the VAT administration in China can be affected by shocks on local governments budget (Chen, 2015a) and it varies over local political cycles (Chen, 2015b).

Figure 1.1: VAT Rate Distribution over China's Manufacturing Firms

Y can be chosen as the numeraire and P is normalized to 1.

Monopolistic competition implies that each firm faces a downward sloping demand curve for its product: $P_i = P \left(\frac{Y}{Y_i} \right)^{1/\sigma}$. The revenue (or the value-added) of each firm can be written as $P_i Y_i = P Y^{\frac{1}{\sigma}} Y_i^{\frac{\sigma-1}{\sigma}} = P Y^{\frac{1}{\sigma}} (A_i L_i)^{\frac{\sigma-1}{\sigma}}$, which is a function of input L_i . Suppose the profit maximizing firm faces the firm-specific tax rate on factor income $w L_i$. Maximizing profit $P_i Y_i - w(1 + \tau_i) L_i$, $i = 1, 2$ over L_i gives rise to the first-order condition: $VMP_{L_i}(L_i) = w(1 + \tau_i)$, where the value of marginal product $VMP_{L_i} = \frac{\partial(P_i Y_i)}{\partial L_i}$. Since VMP_{L_i} is positively proportional to $A_i^{\frac{\sigma-1}{\sigma}} L_i^{-\frac{1}{\sigma}}$, it is downward sloping in L_i . Suppose a benevolent government attempts to achieve the aggregate production efficiency by maximizing GDP subject to the monopolistic competitive market structure and resource constraint $L_1 + L_2 = L$. Obviously, the optimality condition requires $VMP_{L_1} = VMP_{L_2}$ (or equivalently, equal revenue productivity $TFPR_i$, as $TFPR_i = \frac{P_i Y_i}{L_i} = \frac{\sigma}{\sigma-1} VMP_{L_i}$). In a decentralized economy, the production efficiency is achieved if, and only if, there are no tax rate dispersions across firms; that is, $\tau_1 = \tau_2 = \tau$. It could also be put another way: the tax rate dispersion $var(\tau_i)$ leads to *additional* productivity loss aside from the welfare loss caused by the distortionary tax τ itself.

In this model economy, the efficiency loss is caused by the resource misallocation between monopolistic competitive firms. To be specific, the loss comes from the fact that

Figure 2.1: Tax Rate Dispersion and Production Efficiency Loss

the low-tax firm is able to charge a lower price on its product, thus stealing business from its high-tax rival. The magnitude of efficiency loss therefore relies on two factors: (1) the dispersion of tax rate across firms, and (2) the elasticity of substitution between the firms' products.

The idea above can be illustrated in Figure 2.1. The social optimal allocation is determined by the intersection point between VMP_1 and VMP_2 . In a decentralized economy, this can be achieved by setting $\tau_1 = \tau_2$. If $\tau_1 \neq \tau_2$, monopolistic competition gives rise to allocation where $VMP_1 \neq VMP_2$. In the case of $\tau_1 > \tau_2$, high-tax firm (or low-tax firm) is smaller (or bigger) than the social optimal size, as is referred to as resource misallocation. Although the resource allocation is Pareto optimal¹¹, potential gain in GDP/Productivity could still be achieved by re-allocating a certain amount of L from firm 2 to firm 1. The production efficiency loss can be measured by the area of $\triangle ABC \simeq \frac{1}{2}BC \times (BC \times \text{ctg}(\angle A)) = \frac{1}{2}BC^2 \text{ctg}(\angle A)$ ¹², where $BC^2 = [w(\tau_1 - \tau_2)]^2 \propto \text{var}(\tau)$, and $\text{ctg}(\angle A) \sim \text{slope of } VMP_{L_i} \sim \sigma$, where “ $\sim$ ” denotes “to be positively proportional to”.

In a more general setting with more than two firms, we can go even further with particular assumptions and prove $\log TFP = \log TFP^e - \frac{\sigma-1}{2} \text{var}(\log(1 + \tau_i))$, where TFP is the aggregate total factor productivity, and TFP^e is the TFP without tax rate dispersion. Intuition can be illustrated with the following transmission mechanisms: (1) Bigger $\text{var}(\tau) \Rightarrow$ more tax rate dispersion $\Rightarrow$ more resource mis-allocation $\Rightarrow$ more efficiency loss; (2) Higher $\sigma \Rightarrow$ products are more substitutable $\Rightarrow$ more business-stealing by

¹¹Since we can not increase Y_1 without reducing Y_2 , given the resource constraint on L .

¹²In our analysis, I ignore the simultaneous upward shift of VMP_i ($i = 1, 2$) curves because Y increases when the disparity between τ_1 and τ_2 are eliminated. This simplification makes the implication of $\triangle ABC$ more straightforward.

low-tax firm $\Rightarrow$ more resources misallocated from high-tax firm to low-tax firm $\Rightarrow$ more efficiency loss.

At this juncture, a query arise regarding the relationship between the problem of GDP maximization set out above, and the theory of optimal taxation. To see this, I suppose $\left(Y_1^{\frac{\sigma-1}{\sigma}} + Y_2^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ is actually the social welfare function (or utility function of homogeneous consumers). In a standard Ramsey optimal taxation setting, the problem of government can be written as

$$\begin{aligned} \max_{\{L_1, L_2, \tau_1, \tau_2\}} & \left((A_1 L_1)^{\frac{\sigma-1}{\sigma}} + (A_2 L_2)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \\ \text{s.t.} & \begin{cases} L_1 \text{ and } L_2 \text{ in monopolistic competitive equilibrium} \\ (\tau_1 L_1 + \tau_2 L_2)w \geq T \end{cases} \end{aligned} \quad (2.1)$$

where T is the tax revenue requirement of the government. In partial equilibrium where w is taken as exogenous to Ramsey problem (1), one can prove the optimal taxation is characterized by $\tau_1 = \tau_2 = \tau$.

3 Institutional Background of VAT in China

China has introduced VAT as early as 1979. There was a fundamental reform in 1994 on the whole Chinese tax system, which transformed the Chinese VAT into modernity and made the tax codes consistent with those in developed countries. Since 1994, the VAT has been administered by the State Administration of Taxation (SAT). Despite several adjustments has been made over the last decade, its framework remained stable.

3.1 Taxpayers

There are two types of VAT taxpayers in China, acknowledged in terms of the criteria of turnover of sale goods and services, and the condition of their accounting system. One is *general taxpayer*, the other is *small taxpayer*¹³. In the firm survey dataset I use in this paper, all the firms are General VAT taxpayers.

¹³The standard definition of a Small Taxpayer is: (1) where the taxpayer is engaged in the production of goods or in the provision of taxable services as his sole or principal business and his annual turnover is less than one million RMB ¥; or (2) where the taxpayer is engaged in the wholesale or retail of goods and his annual turnover is less than 1.8 million RMB ¥. However, A Small Taxpayer who maintains a sound accounting system and is able to provide accurate accounting records for taxation purposes may be registered as a General Taxpayer.

3.2 Taxable items and tax rates

Tax rates of VAT in China are flat, with differential rates (17%, 13% and 0%) applied to different taxable goods and services. There are three main rates: (1) the standard rate at 17% for most taxable goods and services; (2) the reduced rate at 13% for agricultural goods, public utilities, agriculture production inputs (such as fertilizers and agricultural machinery), books, newspapers, magazines, and other products; (3) the zero rating for exports.

3.3 Tax Exemption and Refund

Items exempted from tax include: (1) some agricultural production materials; (2) contraceptive medicines and devices; (3) antique books purchased from the public; (4) some goods imported for direct use in scientific research, experiment and education, and (5) materials and equipment imported as donations, for poverty relief or other charity purposes.

In the case of the zero tax rate applicable to exported goods, the exporters may apply to the tax authorities for the input tax refund on those particular exported goods. At present, the refund rates vary, at 3%, 5%, 8%, 13% and 17%.

3.4 Tax Authorities

To accommodate the tax revenue sharing system after the 1994 reform, the tax organisations at and below the provincial level are divided into offices of the SAT (State Administration of Taxation) and local tax bureaus.

According to the rules of the State Council on revenue sharing system, the tax revenue in China may be divided into Central tax revenue, local tax revenue and the tax revenue shared between the Central and local governments. Here “local” refers to governments at and below the provincial level, including provincial, municipal, county and village. The tax revenue sharing system between central and local governments was clearly defined in the 1994 reform. Tax revenue shared between the Central and local governments is arranged in the following way: (1) For domestic VAT, 75% is retained by Central Government and 25% is retained by Local Governments. (2) VAT collected by Customs belongs to Central tax revenue.

3.5 Tax Compliance and Tax Administration

Because of the rugged tax codes (differential rates, zero rating, tax refund, etc.) as well as the poor tax administration, the effective VAT rate across firms in China is quite dispersed. More importantly, Table 1 shows that most of the dispersion comes from within

Table 1: VAT Rate Dispersions within (Four-digit) Industries

four-digit industries. This allows us to study the effects of tax rate dispersion on resource allocation among monopolistic firms in the same industry as the theory suggests.

Regarding tax administration, similar to many other developing countries, presumptive taxation and minimum tax are prevalent in China’s taxation practice, especially for the lower tier tax authorities when levying taxes on small enterprises.¹⁴ Another salient feature in China is that State-Owned Enterprises (SOE) have more incentive to comply with the tax code than their non-SOE counterparts. This is largely due to the fact the head of the SOE is generally motivated by pursuing his own promotion as opposed to maximising the firm’s post-tax profit.

In addition to the tax administrative practice mentioned above, evidences show that the VAT administration in China can be affected by incentives faced by the local governments and local politicians. The effective VAT rate may vary over the tightness of local governments budget (Chen, 2015a) and local political cycles (Chen, 2015b).

Figure 3.1 depicts the VAT rate dispersion within a four-digit industry (vegetable/fruit juice or beverages, industry code=1533) in the year 2005. The standard deviation of VAT rate in this industry is the median among all four-digit industries. Compared with Figure 1.1, we do not see significant drop in VAT rate dispersion. This is consistent with the finding in Table 1: most of the dispersion comes from within the industry. Details on analysis of potential sources of the dispersion and related empirical facts could be found in Appendix A.1.

¹⁴For details on the presumptive tax and the minimum tax, readers can refer respectively to Bulutoglu (1995) and Stotsky (1995). Presumptive methods may help reduce audit time and cost. A simple approach is to levy a lump sum on all businesses. A more sophisticated approach involves a census of taxpayers and an estimation of income, assets, turnover, or other alternatives. At the same time, the taxpayers can negotiate their tax liability with tax officials. Since presumptive tax generally comprises a tax on average or “normal” tax base, the marginal tax rate on a tax base above this average tax base is zero, leading to a declining effective average tax rate as the size of the actual tax base increases. Minimum tax is another method for an imperfect tax administration to levy taxes by requiring minimum tax contributions. Generally, tax administration in China is prone to focus on large taxpayers, while rudimentary presumptive methods or minimum tax have to be used for contributions from smaller taxpayers. These practices are usually implemented under limited resources available (such as the number of tax staff, especially staff of superior quality; computers and other facilities) to the tax authorities, and because of the large number of small businesses unable to keep standard accounting books and to file a qualified tax declaration.

Figure 3.1: VAT Rate Distribution over Firm in a Four-digit Industry

4 Theoretical Framework: Distortions and TFP

4.1 Model

The model, largely based on Hsieh and Klenow (2009), aims to map distortions in the firm level into TFP loss at an aggregate level of the whole manufacturing sector. In order to fulfil this goal, we need a model which is able to aggregate the firm production, based on the firm survey data in China, into the total GDP of the whole manufacturing sector.

There are many sub-sectors (such as tobacco production, communication equipment and other similar sectors) within the manufacturing sector, which will be indexed by subscript s in the model.¹⁵

There are three tiers of firms in the manufacturing sector. First, a firm at the bottom, indexed by si , produces Y_{si} using capital and labour as inputs. Second, a firm in the middle, indexed by s , produces Y_s with M_s differentiated inputs $\{Y_{si}\}_{i=1}^{M_s}$. Third, a firm at the top produces final output Y , using $\{Y_s\}_{s=1}^S$ as intermediate inputs.

¹⁵In the firm survey data, s is particularly referred to the four-digit level industry. The classification and code of four-digit level industry are based on the standard of “GB/T 4754—2002” promulgated by the Bureau of Statistics of China in the year 2002. In each sector s , there are lots of production firms, which are indexed by subscript i in the model.

A final output firm uses a Cobb-Douglas production technology:

$$Y = \prod_{s=1}^S Y_s^{\theta_s}, \text{ where } \sum_{s=1}^S \theta_s = 1 \quad (4.1)$$

where Y is the total output in manufacturing sector, and Y_s is the intermediate input bought from sector s . Hsieh and Klenow (2009) assumes a perfect competitive final output market. So the final good producer's objective is to maximize the profit by choosing $\{Y_s\}_{s=1}^S$ and taking prices $P, \{P_s\}_{s=1}^S$ as given.

$$\max_{\{Y_s\}} P \prod_{s=1}^S Y_s^{\theta_s} - \sum_{s=1}^S P_s Y_s \quad (4.2)$$

The above profit maximization problem of the final-output firm yields the following FOCs:

$$P_s Y_s = \theta_s P Y \quad (4.3)$$

Hereafter, we normalize P to 1 by taking final output as numeraire.

Intermediate firm- s produces Y_s with differentiated inputs Y_{si} by CES technology (Dixit-Stiglitz aggregator):

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad (4.4)$$

where σ is the elasticity of substitution between different inputs. Here, the CES technology is introduced to accommodate the monopolistic competition in each four-digit sector s . The price mark-up for the firms in each sector is governed by σ .

The differentiated product Y_{si} is produced by the monopolistic competitive firm with a Cobb-Douglas technology of firm TFP A_{si} , physical capital K_{si} , and human capital H_{si} .

$$Y_{si} = A_{si} K_{si}^{\alpha_s} H_{si}^{1-\alpha_s} \quad (4.5)$$

where $H_{si} = h_{si} L_{si}$, and h_{si} is the firm specific average human capital level, L_{si} is the raw labour input.

Assume that R is the market rental price of physical capital, and w is the wage rate of raw labour. Both R and w are exogenously given, so the model can be justifiably regarded as a partial equilibrium model.

There are two salient features of this model. One is the firm-specific exogenous distortions in output ($\tilde{\tau}_{Y_{si}}$), capital ($\tilde{\tau}_{K_{si}}$) and in labour ($\tilde{\tau}_{H_{si}}$). The objective of firm si is to maximize the profit by choosing P_{si} , Y_{si} , and taking factor prices, distortions, and output demand curve as given.

$$\max_{\{P_{si}, Y_{si}\}} (1 - \tilde{\tau}_{Y_{si}})P_{si}Y_{si} - R(1 + \tilde{\tau}_{K_{si}})K_{si} + w(1 + \tilde{\tau}_{H_{si}})H_{si} \quad (4.6)$$

subject to the downward sloping (inverse) demand curve

$$P_{si} = P_s \left(\frac{Y_s}{Y_{si}} \right)^{1/\sigma} \quad (4.7)$$

where $\tilde{\tau}_{Y_{si}} = 1 - \tau_{Y_{si}} - \tau_{si}^{VAT}$, where τ_{si}^{VAT} is firm specific VAT rate and $\tau_{Y_{si}}$ is other firm-specific distortions in output market.

For narrative purposes, we define the distortion-adjusted factor prices as below.

$$R_{si} = R(1 + \tau_{K_{si}}) \quad (4.8)$$

$$w_{si} = w(1 + \tau_{H_{si}}) \quad (4.9)$$

where $1 + \tau_{K_{si}} = \frac{1 + \tilde{\tau}_{K_{si}}}{1 - \tilde{\tau}_{Y_{si}}}$, $1 + \tau_{H_{si}} = \frac{1 + \tilde{\tau}_{H_{si}}}{1 - \tilde{\tau}_{Y_{si}}}$. By their definition, R_{si} and w_{si} can be viewed as the firm-specific factor prices, which are taken as given by profit-maximizing firm si . Now the firm si 's problem can be re-written as

$$\max P_{si} A_{si} K_{si}^{\alpha_s} H_{si}^{1-\alpha_s} - R_{si} K_{si} - w_{si} H_{si} \quad (4.10)$$

which looks like the normal profit maximization problem of a firm without distortions.

From the firm's profit maximization conditions, we can express the output price for firm i in sector- s as:

$$P_{si} = \frac{\sigma}{\sigma - 1} \frac{1}{A_{si}} \left(\frac{R_{si}}{\alpha_s} \right)^{\alpha_s} \left(\frac{w_{si}}{\beta_s} \right)^{1-\alpha_s} \quad (4.11)$$

where $\frac{1}{A_{si}} \left(\frac{R_{si}}{\alpha_s} \right)^{\alpha_s} \left(\frac{w_{si}}{\beta_s} \right)^{1-\alpha_s}$ is the marginal cost of producing Y_{si} , and $\frac{\sigma}{\sigma-1}$ is the mark-up.

In reality, the distortion-adjusted factor prices, R_{si} and w_{si} , are *unobservable*. But in this model, they can be written as functions of *observable* resource allocations as below.

$$R_{si} = \alpha_s \frac{\sigma - 1}{\sigma} \frac{P_{si} Y_{si}}{K_{si}} \quad (4.12)$$

$$w_{si} = (1 - \alpha_s) \frac{\sigma - 1}{\sigma} \frac{P_{si} Y_{si}}{H_{si}} \quad (4.13)$$

where $P_{si} Y_{si}$ and K_{si} respectively are the value-added and physical capital stock of firm si , which are provided in the firm survey data. Human capital H_{si} is not available in firm survey data. In Hsieh and Klenow (2009), they use the wage bill as proxy for human capital. In this paper, I employ a more direct measurement of H_{si} based on the hedonic wage estimated from the firm survey and the population census.

The following two expressions are to be used in the next section.

First, the expenditure ratio of intermediate input Y_{si} in sector s can be expressed as:

$$\frac{P_{si}Y_{si}}{P_sY_s} = \left(\frac{P_{si}}{P_s}\right)^{1-\sigma} \quad (4.14)$$

Second, the output price index in sector- s is:

$$P_s = \left(\sum_{i=1}^{M_s} P_{si}^{1-\sigma}\right)^{\frac{1}{1-\sigma}} \quad (4.15)$$

4.2 TFP and Production Efficiency

In this section, I explain how to map distortions to aggregate TFP .

Following Hsieh and Klenow (2009), I distinguish two sorts of productivity measurements. One is *physical* productivity, also known as TFP . For firm si , the physical productivity is just A_{si} . Another is *revenue* productivity. For firm si , the revenue productivity can be defined as below.

$$TFPR_{si} = \frac{P_{si}Y_{si}}{K_{si}^{\alpha_s} H_{si}^{1-\alpha_s}} = P_{si}A_{si} \quad (4.16)$$

$TFPR_{si}$ can also be expressed in terms of distortion-adjusted factor prices as follows.

$$TFPR_{si} = \frac{\sigma}{\sigma-1} \left(\frac{R_{si}}{\alpha_s}\right)^{\alpha_s} \left(\frac{w_{si}}{1-\alpha_s}\right)^{\beta_s} \quad (4.17)$$

If there are no distortions, i.e., $\tilde{\tau}_{Y_{si}} = \tilde{\tau}_{K_{si}} = \tilde{\tau}_{H_{si}} = 0$ and $R_{si} = R, w_{si} = w$, then there would be no variation in revenue productivity $TFPR_{si}$ in every sector.

By the same token, I define the revenue productivity for sector s as:

$$TFPR_s = \frac{P_sY_s}{K_s^{\alpha_s} H_s^{1-\alpha_s}} \quad (4.18)$$

where $P_sY_s = \sum_i P_{si}Y_{si}$.

From the results obtained before, $TFPR_s$ can be written as:

$$TFPR_s = \frac{\sigma}{\sigma-1} \left(\sum_i \frac{R_{si}}{\alpha_s} \frac{K_{si}}{K_s}\right)^{\alpha_s} \left(\sum_i \frac{w_{si}}{1-\alpha_s} \frac{H_{si}}{H_s}\right)^{1-\alpha_s} \quad (4.19)$$

where $K_s = \sum_i K_{si}$, $H_s = \sum_i H_{si}$.

Define the TFP in sector s as below:

$$TFP_s = \frac{Y_s}{K_s^{\alpha_s} H_s^{1-\alpha_s}} \quad (4.20)$$

Then we have

$$TFP_s = \frac{1}{P_s} \frac{P_s Y_s}{K_s^{\alpha_s} H_s^{1-\alpha_s}} \quad (4.21)$$

$$= \left[\sum_{i=1}^{M_s} \left(\frac{1}{P_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}} TFP R_s \quad (4.22)$$

$$= \left[\sum_{i=1}^{M_s} \left(A_{si} \frac{TFP R_s}{TRPP_{si}} \right)^{\sigma-1} \right]^{\frac{1}{\sigma-1}} \quad (4.23)$$

Suppose τ_K and τ_H are vectors of distortions in K and H including the VAT rate, and τ'_K and τ'_H are the corresponding distortions excluding the VAT rate. Denote the TFP associated with all distortions as $TFP(\tau_{K_{si}}, \tau_{H_{si}})$, and TFP associated with distortions net of VAT as $TFP(\tau'_{K_{si}}, \tau'_{H_{si}})$. Then the contribution of VAT rate dispersion to TFP loss can be measured as a percentage relative to $TFP(\tau_{K_{si}}, \tau_{H_{si}})$ as below.

$$\text{Contribution of VAT Dispersion} = \frac{TFP(\tau'_{K_{si}}, \tau'_{H_{si}})}{TFP(\tau_{K_{si}}, \tau_{H_{si}})} - 1 \quad (4.24)$$

From Eq. 4.6, I normalize distortion in output $\tilde{\tau}_{Y_{si}}$ and re-define distortions in K and H in the following way.

$$1 + \tau_{K_{si}} = \frac{1 + \tilde{\tau}_{K_{si}}}{1 - \tilde{\tau}_{Y_{si}}}, \quad 1 + \tau_{H_{si}} = \frac{1 + \tilde{\tau}_{H_{si}}}{1 - \tilde{\tau}_{Y_{si}}} \quad (4.25)$$

And the relationship between distortions including τ_{si}^{VAT} and those excluding τ_{si}^{VAT} are expressed as below.

$$\begin{aligned} 1 + \tau'_{K_{si}} &= \frac{1 + \tilde{\tau}_{K_{si}}}{1 - \tau_{Y_{si}}} \approx (1 + \tau_{K_{si}})(1 - \tau_{si}^{VAT}) \\ 1 + \tau'_{H_{si}} &= \frac{1 + \tilde{\tau}_{H_{si}}}{1 - \tau_{Y_{si}}} \approx (1 + \tau_{H_{si}})(1 - \tau_{si}^{VAT}) \end{aligned} \quad (4.26)$$

To obtain Eq. 4.26, I use the fact that $1 - \tilde{\tau}_{Y_{si}} = 1 - \tau_{Y_{si}} - \tau_{si}^{VAT} \approx (1 - \tau_{Y_{si}})(1 - \tau_{si}^{VAT})$.

If there are no distortions, i.e., $\tilde{\tau}_{Y_{si}} = \tilde{\tau}_{K_{si}} = \tilde{\tau}_{H_{si}} = 0$, we would have $TFP R_{si} = TFP R_s$ for all i in each s . Then TFP_s would be simplified as:

$$TFP_s^e = \left[\sum_{i=1}^{M_s} (A_{si})^{\sigma-1} \right]^{\frac{1}{\sigma-1}} \quad (4.27)$$

We call TFP_s^e the efficient TFP in sector s since it is the TFP when there are no distortions.

$$Y_s = TFP_s K_s^{\alpha_s} H_s^{1-\alpha_s} \quad (4.28)$$

Therefore, the TFP loss caused by all distortions in sector s can be measured by $1 - \frac{TFP_s(\tau)}{TFP_s^e}$ as a percentage relative to efficient TFP_s^e , where $TFP_s(\tau)$ is the TFP in sector s under a vector of distortions τ .

5 Data

5.1 Firm Survey

The firm data used in this paper is the same as the one used by Hsieh and Klenow (2009). It is the *Annual Survey of Industrial Production* conducted by the Chinese National Bureau of Statistics. The survey includes all non-state firms with more than 5 million RMB Yuan in revenue (about \$800,000) plus all state-owned firms. I use the data from the year 2000 to 2007. There are over 160,000 firms in each year. Each firm has a four-digit industry code, ownership, region code, wage payments, value-added, capital stock, and a number of employees.

I use total asset as the physical capital stock, while Hsieh and Klenow (2009) use the book value of the fixed capital net of depreciation. The main discrepancy between the two are current assets and intangible assets, which are supposed to create values-added to firms as well and therefore should not be ruled out once they are available in the dataset. Otherwise, I would get incorrect TFP for each firm and thus inappropriate TFP dispersion across firms.

The wage compensation includes following items: (1) payable wage; (2) unemployment insurance premium; (3) pension and medical insurance premium; (4) housing mutual fund; and (5) total welfare fees. The average wage compensation as a share of value-added is only 34%, while it is about 50% in the input-output table of China's economy. To deal with this problem, I use the same method as Hsieh and Klenow (2009) by adjusting the wage compensation with a constant factor (multiplied by 3.6 in our case) such that the average wage compensation share is approximately 50%.

To ensure data quality, I dropped three types of observations: (1) the observation with empty cell; (2) the observation with non-positive value for capital stock, labour input, value-added and wage compensation; and (3) the observation with value-added less than the wage (even without adjustment in wage, the value-added in many firms is also less than the wage compensation). In the end, we are left with number of firms ranging from approximately 66,000 to 168,000 in each year during the period from 2000 to 2007.

Table 2 briefly reports the summary statistics of several key variables in the firm survey

from the year 2000 to 2007.

Table 2: Summary Statistics – Firm Survey (2000 - 2007)

5.2 Population Census

Another important issue is the measurement of human capital. In Hsieh and Klenow (2009), they use the wage bill of each firm to proxy its human capital. In this paper, I attempt to improve the human capital measurement based on a hedonic wage equation by incorporating information about wages, years of schooling and other relevant characteristics of the labour force in the 1% Sampling Population Census (or Mini Census) in year 2005.¹⁶ The Census was conducted by the Chinese National Bureau of Statistics. There are 2,585,481 individuals in the data set. The variables I use in this paper are: educational attainment, completion of schooling, main source of income, two-digit industry code, and the ownership of the firm where the individual is working. To check the robustness of the results of this paper in the later stage, I may still want to use other variables such as: year and month of birth, sexual orientation, two-digit address code, ethnicity, monthly income, and occupation.

I dropped the following observations: (1) those not working in the manufacturing sector; (2) those whose occupation is ‘farmer’ or non-firm employee; (3) those whose main source of income is not from labour and from assets. After this filtering process we were finally left with about 200,000 observations.

The population census data and the firm survey data can be matched in the year 2005 by the industry-provincial-ownership characteristics. There are thirty-nine two-digit manufacturing industries, thirty-one provinces, and two types of ownership (state-owned and non-state-owned). The match between the two data sets allows us to estimate the human capital for each firm in the firm survey data.¹⁷

Table 3 briefly reports the key variables in the population census.

¹⁶Details of this work are discussed in the Appendix.

¹⁷Refer to Appendix for technical details on human capital estimation.

Table 3: Summary Statistics – Population Census (2005)

6 Main Results

6.1 Calibration and Computation Procedure

To quantify the contribution of the dispersion in the effective VAT rate, in the first instance I need to calibrate several parameters of the model in Section 4. Following Hsieh and Klenow (2009), I set $\sigma = 3$. In a different way, I calibrate α_s to the firm survey data in China.¹⁸ Regarding R and w , I calibrate them, based on the firm survey data, respectively to the average rental price of capital and wage rate in the whole manufacturing sector.

Then, following steps below, I calculate the contribution of distortions to TFP loss.

Step 1: Based on Eq. (4.12) and Eq. (4.13), R_{si} and w_{si} can be calculated from the value-added $P_{si}Y_{si}$, physical capital stock K_{si} , and human capital stock H_{si} . $P_{si}Y_{si}$ and K_{si} are available from the firm survey data. H_{si} is the human capital stock.

Step 2: Given R_{si} and w_{si} obtained from step (1), I back out $\tau_{K_{si}}$ and $\tau_{H_{si}}$ based on Eq. (4.8) and Eq. (4.9).

Step 3: Calculate $TFPR_{si}$ based on Eq. (4.17).

Step 4: Calculate $TFPR_s$ based on Eq. (4.19).

Step 5: Calculate TFP_s based on Eq. (4.21).

Step 6: Following Hsieh and Klenow (2009), A_{si} can be calculated from the following equation: $A_{si} = \frac{(P_{si}Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s} H_{si}^{1-\alpha_s}}$.

Step 7: Calculate TFP_s^e based on Eq. (4.27).

Step 8: Calculate the *Contribution of VAT dispersion* from Eq. (4.24).

6.2 VAT Rate Dispersion and TFP/GDP Loss

In this section, I report the TFP loss respectively under two sets of distortions in the output: (1) With all distortions $\tilde{\tau}_{Y_{si}} (= \tau_{Y_{si}} + \tau_{si}^{VAT})$; (2) With only $\tau_{Y_{si}}$, that is, the distortions excluding firm specific VAT rate τ_{si}^{VAT} .

The results are reported in Table 4. It should be noted that I assume τ_{si}^{VAT} is independent of $\tau_{Y_{si}}$, $\tilde{\tau}_{K_{si}}$, $\tilde{\tau}_{H_{si}}$. This implies that the distribution of other distortions ($\tau_{Y_{si}}$, $\tilde{\tau}_{K_{si}}$, and $\tilde{\tau}_{H_{si}}$) would not change when I eliminate the VAT rate dispersion (τ_{si}^{VAT}). In next section, I will relax this assumption and check its impact on the baseline results.

Table 4: Dispersions in VAT and TFP/GDP Loss

¹⁸Hsieh and Klenow (2009) calibrate α_s to the corresponding number in the U.S.. I have two reasons for doing in a different way. First, unlike Hsieh and Klenow (2009), I do not compare the distortions between China and the U.S., so I do not need the U.S. as a benchmark. Second, in theory, the appropriate technology in China should be different from that in the U.S. due to different endowments (say, the proportion of skilled labour) in these two countries. It is hard to believe that China's capital share would be the same as that of U.S.

In row (1) of Table 4, I calculate the TFP loss caused by all the distortions $\tilde{\tau}_{Y_{si}}$. It is measured by $1 - TFP(\tau'_{K_{si}}, \tau'_{H_{si}})/TFP^e$, where $\tau'_{K_{si}}, \tau'_{H_{si}}$ respectively are the distortions in K and H normalized by $\tilde{\tau}_{Y_{si}}$ based on Eq.(4.25).¹⁹

In row (2) (TFP Loss Net of VAT), I calculate the TFP loss caused by all the distortions $\tilde{\tau}_{Y_{si}}$. It is measured by $1 - TFP(\tau_{K_{si}}, \tau_{H_{si}})/TFP^e$, where $\tau_{K_{si}}, \tau_{H_{si}}$ are the distortions in K and H normalized by $\tau_{Y_{si}}$ based on Eq.(4.26).

In both row (1) and row (2), I regard TFP^e , the efficient TFP in a world without any distortions, as the benchmark.

The main results of the paper are reported in Row (3). The “Contribution of VAT” is measured by $\frac{TFP(\tau_{K_{si}}, \tau_{H_{si}})}{TFP(\tau'_{K_{si}}, \tau'_{H_{si}})} - 1$, which can be interpreted as the percentage GDP/TFP gain from removing the VAT rate dispersion (τ_{si}^{VAT}) compared with the current actual GDP/TFP ($TFP(\tau'_{K_{si}}, \tau'_{H_{si}})$). As an additional information, row (4) reports the mean of the effective VAT rate within industries.

From row (3) we can see that the contribution of VAT rate dispersion to GDP (or TFP) loss is characterized by its significant magnitude and big volatility. On average, the percentage of TFP (or GDP) loss is about 7.9% during the period from 2000 to 2007. Over time, it ranges from 5% to 16%. In contrast, the average effective VAT rate in row (4) is largely unaffected. This counter-factual exercise is close to a revenue-neutral tax reform since it only eliminates the spread between the firm-specific VAT rate and the economy-wide average VAT rate, with the tax rate for the high-tax firm being lowered and for the low-tax firm being raised. Therefore, the government is able to increase the aggregate TFP and GDP by reducing dispersion in the effective VAT rate while keeping the total tax revenue unchanged.

6.3 Correlation with Other Distortions and Productivity

In the analysis I have done for Table 4, I assume τ_{si}^{VAT} is independent of both other distortions $\tau_{Y_{si}}, \tilde{\tau}_{K_{si}}, \tilde{\tau}_{H_{si}}$, and productivity A_{si} . However, the plausibility of this assumption is still questionable. In addition, readers may wonder to what extent the conclusion would change if this assumption was violated. The quantitative analysis below delivers

¹⁹In this paper, TFP loss is measured by the percentage change of TFP relative to the *efficient* TFP . While in Hsieh and Klenow (2009), it is measured relative to the *actual* TFP . However, this does not affect the measurement of the contribution of VAT. Two time patterns in TFP loss can be observed from Table 4. First, the TFP loss seems to ride on a upward trend during 2000 - 2007. This is consistent with the finding of increasing TFP losses in China after mid-1990s by Brandt et al. (2013). Second, the TFP loss seems to jump above the trend in year 2002, 2003, and 2007. Similar findings are reported in Section 7.2. The timing coincides with the national-wide political turnover in association with the National Congress of Chinese Communist Party in year 2002 and 2007, which might have been then churning up distortions and raising the TFP losses. This is supported by circumstantial evidences. For example, Chen (2015b) finds that the taxation and credit allocation in China is affected by the local political cycle. Zhou et al. (2013) find that the mis-allocation at the provincial level deteriorates in the year of local congress of the Chinese Communist Party, and its negative impact lasts over the next two years.

positive response to that doubt – relaxing these assumptions does not make a considerable difference from the baseline results.

Table 5 shows that correlation coefficients between five variables in the model. The numbers in the first column suggest that the correlation between the VAT rate and other distortions, as well as productivity $\ln A_{si}$ are very low.

Table 5: Correlation between Distortions and Productivity

As Hsieh and Klenow (2009) suggest, the variance of logarithm of revenue productivity ($TFPR$) across firms is a sufficient statistics of percentage TFP loss.²⁰ And the variance of logarithm of revenue productivity ($TFPR$) can be decomposed as below.

$$\begin{aligned} var(\ln TFPR_{si}) &= var(\ln(1 - \tau_{si}^{VAT}) + \ln TFPR_{si}^{KH}) \\ &= var(\ln(1 - \tau_{si}^{VAT})) + var(\ln TFPR_{si}^{KH}) \\ &\quad + 2cov(\ln(1 - \tau_{si}^{VAT}), \ln TFPR_{si}^{KH}) \end{aligned} \quad (6.1)$$

where $\ln TFPR_{si}^{KH} = \alpha_s \ln(1 + \tau'_{K,si}) + (1 - \alpha_s) \ln(1 + \tau'_{H,si})$.

According to Expression 6.1, the contribution of τ^{VAT} to the TFP loss is underestimated by $cov(\ln(1 - \tau_{si}^{VAT}), \ln TFPR_{si}^{KH})$ when we assume that there is no correlation between $\ln(1 - \tau_{si}^{VAT})$ and $\ln(1 + \tau'_{K,si})$, or $\ln(1 + \tau'_{H,si})$. Table 5 shows the correlation between $\ln(1 - \tau_{si}^{VAT})$ and $\ln TFPR_{si}^{KH}$ is equal to 0.0009, very close to zero. It implies a negligible mis-calculation in the baseline results.²¹

7 Robustness Check

7.1 Export Refund

Export tax refund is a potential source of dispersion in the effective VAT rate. To see how much it may lead to TFP loss, I do the robustness check by recovering the counterfactual VAT rate for each firm. I do this by removing the export refund in the same way as we did in Table A.7 of Appendix.

The results are reported in Table 6. Row (1) is the contribution of VAT rate dispersion to GDP/TFP loss after removing the export refund. Row (2) is the benchmark case with

²⁰Hsieh and Klenow (2009) prove that the following expression for TFP in a four-digit industry s : $\ln TFP_s = \frac{1}{\sigma-1} \log \left(\sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} var(\ln TFPR_{si})$, if $\ln(1 - \tau_{si}^{VAT})$, $\ln(1 + \tau'_{K,si})$, $\ln(1 + \tau'_{H,si})$, $\ln A_{si}$ satisfy the normal distribution.

²¹Specifically, the mis-calculated TFP loss can be captured by $\frac{\sigma}{2} \times 2cov(\log(1 - \tau_{si}^{VAT}), \log TFPR_{si}^{KH})$. Given $\sigma = 3$, we have $\frac{\sigma}{2} = 1.5$. The number is equal to $1.5 \times 0.0009 \times 0.1451 \times 1.1036 \times 100\% = 0.0216\%$. So we underestimate the TFP loss caused by VAT rate dispersion in Table 4 only by a negligible magnitude of 0.0288%. Even if σ increased to an extremely large value as 10, the underestimated TFP loss is still just 0.145%.

export refund. Compared to row (2), the numbers in row (1) are not significantly and systematically larger or smaller, suggesting a minor role of export tax refund in TFP loss.

Table 6: TFP Loss with VAT Tax Refund Excluded

7.2 Time-idiosyncratic Shocks

Is the TFP loss caused by VAT rate dispersion mainly attributed to firm-fixed effect or to time-idiosyncratic shocks on VAT rate? To answer this question, I take the time average of VAT rate over the firms in six sub-samples. To do this, I need to link a firm over years. However, since the firm ID changed in the year 2004, we can only link the firms respectively in two periods: from 2000 to 2003, and from 2005 to 2007.²² In each period, we consider several sub-samples of firms which stay for certain years.

For every firm in each sample, we take the year average of the VAT rate. In Sample 1, the year average is taken over four years for all firms in the sample. In Samples 2 and 5, the year average is taken over three years for all firms in the sample. In Samples 3 and 6, the year average will be actually taken over only two years for some firms. In Samples 4 and 7, the year average is just the actual VAT rate in a year within the period.

In Table 7 and Table 8, I report the “Contribution of VAT” of the effective VAT rate in each year and the year-average over the period, by using the same method to calculate the “Contribution of VAT” to TFP/GDP loss as in Section 6.

Table 7: TFP Loss with Time Average of VAT Rate (2000-2003)

Table 8: TFP Loss with Time Average of VAT Rate (2005-2007)

The results in Table 7 and Table 8 imply that the year-average does not reduce the contribution of VAT, and the firm-fixed effect plays a major role in the VAT rate dispersion across firms. This can be seen by comparing the numbers in different columns, for firms staying for the whole period (Samples 1 or 4), the “Contribution of VAT” of year-average (1.5% in 2000 to 2003, 4.0 in 2005 to 2007) does not differ too much from that of each year, except in the years 2002 and 2007.

Then we can make a comparison between different rows along the same column. We can clearly see that the “Contribution of VAT” is increasing in the sample size (Sample 4 > Sample 3 > Sample 2 > Sample 1, and Sample 7 > Sample 6 > Sample 5). This suggests that the entry and exit of firms brings about additional contribution to

²²This is a convenient way to link firms. It is acceptable because my focus is not to study firm dynamics. Brandt et al. (2012) propose a more complicated way to link firms during the whole sample period in the same dataset by using various firms’ unique characteristics such as firm name, address, telephone, etc.

TFP loss. This is mainly because the entry-exit firms are more distorted in capital and labour market and thus reduce the actual $TFP(\tau'_{K_{si}}, \tau'_{H_{si}})$ and increase the contribution $TFP(\tau_{K_{si}}, \tau_{H_{si}})/TFP(\tau'_{K_{si}}, \tau'_{H_{si}}) - 1$, rather than because the VAT rates are more dispersed over these firms and reduce the $TFP(\tau_{K_{si}}, \tau_{H_{si}})$.

In addition, the years 2002 (4.9%) and 2007 (12.6%) themselves differ significantly from other years in each period. As discussed in Section 6.2, a very plausible explanation is that it is driven by political cycle associated with the National Congress of the Chinese Communist Party, which took place in year 2002 and 2007.

7.3 Data Quality

Data quality is another concern about this research. In this section, I respond to this doubt, by double-checking the data both from the Bureau of Statistics (the Firm Survey I use in this paper) and that from the State Administration of Taxation.

Unfortunately, the firm level tax data is not available from the State Administration of Taxation. However, the State Administration of Taxation releases the *Tax Burden Ratio* for each two-digit industry and its lower bound as a warning signal regarding firms' tax evasion. *Tax Burden Ratio* is defined as $\frac{\text{Payable VAT}}{\text{Sales Value}}$. The State Administration of Taxation of China calculates the "Guideline" and "Lower Bound" of VAT burden ratio of each industry based on the firm level tax data over previous years. The "Guideline" is the average VAT burden ratio for firms within industry. The "Lower Bound" and "Upper Bound" is just the analogue to the confidence interval in statistics.

Figure 7.1 shows the "Guideline", "Lower Bound", and the "Upper Bound" from the State Administration of Taxation and the average VAT rate in the Firm Survey of each two-digit industry. Among 40 two-digit industries, 9 industries lie outside of the warning bound.

Table 9 reports the results of a robustness check by dropping from the sample the 9 industries which stay out of the warning bound. Several conclusions can be drawn. First, the contribution of VAT dispersion to TFP loss does not change systematically by excluding the 9 industries. That can be seen by comparing row (1) and row (2). Second, the average of the effective VAT rate in the remaining sample is almost unchanged. Third, the TFP loss caused by other distortions systematically decreases for all years. This implies that the firms in these data-inconsistent industries also suffer from more distortions in capital and labour markets.

Table 9: TFP Loss with Checks on Data Quality

Figure 7.1: Data Quality Check

7.4 Outlier

Another potential problem with the firm survey data is that outliers could exaggerate the contribution of VAT rate dispersion to TFP loss if a small number of firms extremely over-report or under-report their VAT liability and drive up the dispersion in the effective VAT rate. To avoid the contamination by outliers, I drop $2\alpha\%$ firms from the whole sample in each year if a firm's effective VAT rate is below $\alpha - th$ percentile or above $(100 - \alpha) - th$ percentile in that year.

Table 10 reports the results after dropping 0.1% of firms ($\alpha = 0.05$). We can see that the results are not affected, except in the years 2006 and 2007, where the contribution of VAT dispersion to TFP loss significantly decreases to the average level rather than much below the average.

Overall, the greater α is, the less dispersed is the effective VAT rate, and the contribution of VAT dispersion to TFP loss may also decrease. But is $\alpha = 0.05$ a reasonable setting? The answer is probably 'yes'. To observe this, I report in Table 10 the minimum and maximum of the effective VAT rate after dropping the outliers. The minimum is -30% and the maximum is 100%. According to the tax law and tax practice in China, these are not extraordinary numbers even in the absence of tax evasion. Therefore, there is no strong evidence that we still need to raise the value of α .

Table 10: TFP Loss with Outliers Excluded

7.5 Elasticity of Substitution

As we have shown in Section 1, greater elasticity of substitution can translate into more TFP loss. This is because, with a greater elasticity of substitution, a low-tax firm can steal more business from a high-tax firm and this leads to more resource mis-allocation.

Following Hsieh and Klenow (2009), we also do the robustness check with greater elasticity by setting $\sigma = 5$ and report the result in row (1) of Table 11. Similar to what Hsieh and Klenow (2009) find, the TFP loss of all distortions is aggravated massively, and the contribution of VAT is also enormously amplified compared to benchmark results in row (2) with $\sigma = 3$. This suggests that the results are sensitive to the parameter value of σ . To get convincing results, more work needs to be done in the future to estimate σ .

Table 11: TFP Loss with $\sigma = 5$

7.6 VAT Reform

A consumption type VAT tax reform was initiated in six industries in Northeast provinces in July 1, 2004.²³ Could the *TFP* loss be affected by the VAT reform in north-east provinces in 2004? To answer this question, I dropped all firms in eight industries as well as the three provinces involved in the reform. The results are reported in row (1) of Table 12 and show that the contribution of VAT to TFP loss does not change very much compared to the benchmark results in row (2), except where it decreases significantly in year 2007. In other years, it may increase or decrease a little bit, without a systematic direction of movement.

Table 12: TFP Loss with VAT Reform Provinces and Industries Excluded

8 Conclusion

Among all possible distortions that lead to misallocation and produce efficiency loss, the effective VAT rate might not be the most salient one, however, it is a measurable one. This allows us to study the impact of dispersion in the effective VAT rate on the

²³With VAT being transformed from product type to consumption type, firms in these industries in Northeast provinces face a lower effective VAT tax rate than those in other regions. In July of 2007, the reform was extended to another twenty-six cities in six central-region provinces. Tax reforms are generally launched only in some selected industries and regions, as oppose to implementing at once in all industries and in the whole country.

aggregate production efficiency. Based on the structural model and approach initiated by Hsieh and Klenow (2009), I conduct a counter-factual analysis by removing the VAT rate dispersion to calculate the potential TFP/GDP gain. The results show that the TFP/GDP gain is as large as an average order of 7.9%, and volatile too, ranging from 5% to 16% in the period from 2000 to 2007. This suggests that the VAT in China can lead to non-negligible distortions and misallocation. In addition, revenue-neutrality is as well an appealing feature of such kind of tax reform – governments only need to focus on eliminating tax rate dispersion while leaving the tax rate at a level sufficient to bring in a given amount of total tax revenue. Given the importance of VAT in China and its popularity around the world, welfare gain from any feasible VAT reform could be gigantic.

Robustness checks suggest that the efficiency loss mainly comes from the time-persistent and firm-specific factors rather than the time-varying shock; the data quality is not a problem; while the results are sensitive to the parameter value of elasticity of substitution. The correlations are close to zero between the firm’s VAT rate and some of the firm’s characteristics, including firm size, productivity, distortions in capital and in labour. This suggests that the elimination of VAT rate dispersion does not necessarily involve changes in other distortions. It also implies that the VAT distortion in China is neither a “size-dependent policy”, nor positively correlated with firm productivity and therefore extremely nocuous to TFP.

One caveat should be noted in the end. The effective VAT rate dispersion could be caused either by intricate real-world tax codes or by poor tax administration.²⁴ This paper is still silent on the respective role of each. Further studies could be done by separating the contribution of the two to the production efficiency. An additional feasible way is to employ the firm level data in developed countries such as UK and France, and to set their effective VAT distribution as a benchmark in the counter-factual exercise, rather than using the dispersion-free distribution in China itself as the benchmark as I have done in this paper.

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²⁴This is because the effective VAT rate dispersion is due to two broad factors: either tax law (e.g., the existence of a general and reduced rates, rebates for exports and zero-rated goods), or the enforcement of law (e.g., tax evasion, corruption, etc.). The TFP efficiency loss calculated in this paper should be attributed to either factor.

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Appendix 1. Effective VAT Rate Dispersion – Potential Sources and Facts

A.1.1 Potential Sources of VAT Dispersion

Theoretically, the value-added tax (VAT) avoids cascade effects of sales tax by taxing only the value-added at each stage of production. An ideal VAT system is supposed to apply a uniform tax rate at every stage along the value-added chain, concluding at the final consumption. Without doubt, the effective VAT rate for different taxpayers would be the same under a perfect VAT system.

In practice, however, the effective VAT rate varies across firms due to various reasons: (1) The breakdown of the value-added chain; (2) A non-uniform tax rate; (3) Tax compliance; (4) Tax administration and enforcement; (5) Tax reforms. To be consistent with the motivation of this paper, I focus primarily on the sources of the VAT rate dispersion within the same (four-digit) industry, as opposed to discussing the VAT rate differentials between firms in different industries.

The sources of effective VAT rate dispersion can be demonstrated by a credit-invoice computation method:

$$\tau = \frac{p_y q_y \tau_y - p_m q_m \tau_m}{p_y q_y - p_m q_m} = \left(1 - \frac{p_m q_m}{p_y q_y}\right)^{-1} (\tau_y - \tau_m) + \tau_m \quad (\text{A.1})$$

where τ is the effective VAT rate of a firm. p_k, q_k, t_k ($k = y, m$) respectively are price, quantity, and tax rate for goods k ($k = y$ for output, $k = m$ for intermediate input). $p_y q_y - p_m q_m$ is value-added. $p_y q_y \tau_y$ is the tax payment on sales, $p_m q_m \tau_m$ is the reclaimable tax on intermediate goods purchase. $p_y q_y \tau_y - p_m q_m \tau_m$ is payable VAT.

Theoretically, if $\tau_y = \tau_m = 17\%$ for all firms, then there would be no cross-firm dispersion in τ . But dispersion arises in two cases: (1) Even though all firms have the same

τ_y and the same τ_m , while if $\tau_y \neq \tau_m$, then the disparity between firms in $(p_m q_m)/(p_y q_y)$ would imply the dispersion in τ . (2) If $\tau_y = \tau_m$ for each firm, but they vary across firms, then we still have dispersion in τ . These two cases may arise from several sources including tax law, tax compliance, tax administration and enforcement, and tax reform in China, and this is discussed in greater detail below.

Break-down of the Value-added Chain

If all transactions are included in a VAT system and are applied with the same flat tax rate, there would be no tax rate dispersion across firms. But a breakdown of the value-added chain gives rise to VAT rate dispersions. Below are two common cases in China.

First, service sectors are excluded from VAT system. In China, exemption of many service sectors from the VAT system does not allow the manufacturing firms that purchase services from other firms to reclaim on its service input. In this case, $\tau_m = 0$ for the service intermediate input purchased from other firms. Even though all firms face the same output tax rate τ_y , the firm with smaller $(p_m q_m)/(p_y q_y)$ benefits from lower effective VAT rate τ . A manufacturing firm, therefore, has an incentive to vertically integrate service firms and purchase less intermediate input $p_m q_m$ in order to reduce τ . Different $(p_m q_m)/(p_y q_y)$ across firms, probably due to firms' heterogeneous capability of vertical integration, would result in tax rate dispersion.

Second, invoices are difficult to get from purchasing agricultural goods. In China, it is very common that manufacturing firms (say, tobacco factories) purchase the agricultural goods (say, tobacco leaves) as their raw material from farmers who in general are not able to provide the invoice. In this case, $\tau_m = 0$. By the same token, a firm will face a low τ if it sets up an agricultural farm of its own, or if it is able to purchase from large formal farms which can provide invoices for their agricultural products.

Non-uniform Tax Rate

There are three common cases of deviation from the standard VAT rate at 17%.

First, differential tax rates. In China, the VAT rate is 17% at the standard rate but only 13% for agricultural goods. In this case, $\tau_y > \tau_m$. A firm can lower τ by vertically integrating an agriculture farm as a supplier of intermediate input.

Second, export refund and zero rating. In this case, $\tau_y < \tau_m$. Suppose two firms produce the same product. Firm D produces solely for the domestic market, while Firm E exports to foreign markets. Firm E can get the VAT tax refund and enjoy a lower effective tax rate than Firm D.

Third, purchase of goods from small taxpayers. In China, a tax reclaim on a purchase from small taxpayers is lower than the standard rate, which implies $\tau_y > \tau_m$. In this case,

a firm will have a higher tax rate if it has to purchase the intermediate input from small taxpayers.

Tax Compliance

Although the system of VAT is superior to other systems in terms that it limits the scope of tax evasion or fraud by tracing down invoices in transaction, tax compliance is still a big concern in practice. HMRC in the UK estimates that the “VAT gap” was 11.5 billion, accounting for 14% of the potential revenue yield, from 2009 to 2010; that is the difference between tax actually collected and the tax that would have been paid. (Mirrlees *et al.*, 2011).

Non-compliance can occur in following ways:

First, firms do not record sales that ought to be taxable. A firm can open a direct sales store without issuing invoices to consumers, or launch a sales promotion just by bestowing goods as opposed to lowering the price. Thus τ_y could be different between firms.

Second, invoices for input purchases can be faked. A firm can buy agricultural goods from non-VAT taxpayers. So τ_m could vary across firms.

Third, firms can claim that sales are lower-rated or zero-rated. A firm can fake export invoices. τ_m could vary across firms.

In addition, China still has a non-negligible number of SOE, and these may be more compliant when paying tax than Non-SOE.

Tax Administration and Enforcement

China is a huge country with substantial geographical heterogeneity. VAT is collected by SAT (State Administration of Taxation). Under the hierarchical structure of SAT, regional differences in tax administration and enforcement can be enormous, at least for two reasons. First, the principal-agent relationship between taxation officials at different levels of SAT involves asymmetric information problems in tax collection. Second, taxation officials at lower levels of SAT, for instance at a county level, are very likely to be connected with local government officials, and thus act in favour of local interests rather than in accordance with tax law. Regional VAT rates, therefore, are determined to a large extent by regional factors such as the taxation capability, the agency cost, the administration cost, and the incentive of taxation enforcement (Chen, 2015a, b).

In addition, the delay in VAT payment is also a common practice in China. It usually takes place when a firm has used up all their cash and has to make a request to the taxation office for an extension of time to make their tax payment. In this case, a firm's τ could vary over time, but its overall time average should remain stable.

Tax Reform

Tax reforms are generally launched initially only in some selected industries and regions, as opposed to implementing them all at once across all industries and in the whole country. This gradualism in reform may create tax rate dispersions across regions and industries. For example, VAT tax reform was initiated in eight industries in the north-east provinces on July 1, 2004, with VAT being transformed from a product type to a consumption type, which led the firms in these industries in north-east provinces to experience a lower effective VAT tax rate than those in other regions. In July 2007, the reform was extended to another twenty-six cities in six central-region provinces. In this case, τ_m could be different for firms in different regions within the same industry.

A.1.2 Empirical Facts on VAT Dispersion

Although there are many potential sources of VAT rate dispersion, as laid out above, the regression results in this section suggest that the main factor is the regional variation, which accounts for about 60% of within-industry VAT rate dispersion. Observable tax compliance and tax planning behaviours, such as vertical integration, size and ownership of the firm, do also significantly affect the VAT rate, but with a notably smaller contribution to VAT rate dispersion.

The results also show that consumption type VAT reform reduced the VAT rate dispersion in reform industries, while the time-idiosyncratic shock, export refund, entry and exit of firms are not a main source of tax rate dispersion.

Tax Administration, Compliance, Ownership

To empirically investigate the sources of VAT rate dispersion, I run the following regression, in an attempt to measure the impact of regional fixed effect, ownership type of firm, and various other characteristics of a firm including its size, input-output structure, reliance on exports, organisation of firm, after controlling for four-digit industry and year fixed effects. The regression equation is as follows:

$$\tau_{it} = \alpha + \gamma_t + \eta_{c,s} + \gamma SOE_i + \eta Size_{it} + \lambda Organization_{it} + \delta Export_{it} + \xi_{it} \quad (A.2)$$

where γ_t and $\eta_{c,s}$ respectively are year fixed effects and county-(4-digit)industry fixed effect, SOE_i is dummy for ownership type ($SOE_i = 1$ for Non-SOE). $Size_{it}$ is measured by logarithm of firms' value-added, $Export_{it}$ by $\frac{Export}{Total\ sales}$. Organization of a firm is measured by two variables: (1) input-output structure $\frac{p_y q_y - p_m q_m}{p_y q_y}$, (2) number of establishments.

Results in Table A.1 bear some implications. The R^2 changes from close to zero in

Table A.1: Sources of VAT Rate Dispersions

column (1) to 0.06 in column (2). This suggests that about 6% of the cross-firm variation in the effective VAT rate can be explained by the variation across (4-digit) industries. By the same token, the R^2 in column (3) and (4) implies that the county fixed effect and the (4-digit) industries-county fixed effect have explanation power at an magnitude of about 11% and 44% respectively. The results in column (5) suggests that, even after controlling for some observable firms' characteristics that should affect the effective rate, there are still about 45% of the variation remains unexplained.

Since $\tau = \frac{p_y q_y \tau_y - p_m q_m \tau_m}{p_y q_y - p_m q_m} = \frac{p_y q_y}{p_y q_y - p_m q_m} \tau_y - \frac{p_m q_m}{p_y q_y - p_m q_m} \tau_m$, we also want to know the sources of dispersion in τ_y and τ_m . Similarly, I regress τ_y and τ_m on the same regressors as Table A.1, where τ_m is measured by $(Input\ VAT)/(Intermediate\ goods\ purchase)$, τ_y is measured by $(Output\ VAT)/(sales\ turnover)$. The results are reported in Table A.2 and Table A.3.

The R^2 in column (3) of table A.2 is 0.53. This is in contrast to that in column (1) and (2), and implies that about 53% of the variation in the effective input VAT rate can be explained by persistent county fixed effects, while the industry fixed effects have no impact at all. This might be explained by problematic local VAT administration, particularly due to firms using fake invoice for VAT reclaim, as suggested by Chen (2015a, b). By comparison, the R^2 in column (3) of table A.3 is only 4%. And it is as big as 0.83 in column (5), suggesting that the variation in the effective output VAT rate is probably explained by the statutory factors rather than by poor tax administration.

Table A.2: Determinants of Input VAT Rate

From Table A.3 we can obtain following implications.

First, the county fixed effect can account for approximately 70% of the dispersion in τ_y across firms within an industry.

Second, a firm's ownership, size, export refund, and number of establishments account for approximately 19% of τ_y .

Table A.3: Determinants of Output VAT Rate

Tax Reform

An eyeball test from the summary statistics in Table A.4 suggests that the consumption-type VAT reform in 2004 does lead to some changes in VAT rate dispersion for the north-east provinces, It dropped from around 13% before reform to 11% of the post-reform level.

Table A.4: VAT Rate and Reform – Summary Statistics

To see the precise effect of tax reform on the effective VAT rate, I employ the triple difference approach (DDD), by looking into the variation over periods (before and after reform), across regions (three north-east provinces and others), and across industries (industries under reform and others). I respectively regress the VAT rate of firm i in year t (τ_{it}) and standard deviation of τ_{it} within an industry-region-period cell ($Std(\tau_{it})$) on three dummies and their cross-terms as follows:

$$\begin{aligned} \tau_{it}(\text{or } Std(\tau_{it})) = & \alpha + \beta R_i^{NE} + \gamma I_i^s + \eta Y_t^{After} + \theta R_i^{NE} Y_t^{After} \\ & + \delta I_i^s Y_t^{After} + \kappa R_i^{NE} I_i^s + \varphi R_i^{NE} I_i^s Y_t^{After} + \xi_{it} \end{aligned} \quad (\text{A.3})$$

where the parameter of interest is φ .

The regression results are reported in Table A.5. The results show that the reform in six industries in three north-east provinces reduces the effective VAT rate by 0.76% (insignificantly) and decreases its standard deviation by 1.25% (significantly at 5% level). In Section 7, I check whether the TFP loss caused by VAT rate dispersion calculated in the baseline result can be significantly changed by excluding reform region and reform industries from the sample.

Table A.5: VAT Rate and Reform – Regression

Time-idiosyncratic Shock

One may partly explain the VAT rate dispersion as a result of taxpayer's time-idiosyncratic behaviour, such as the delay of VAT payment this year until next year because of cash constraints. Admittedly, this is not unusual in China's practice. If we suppose that this is an important factor affecting the tax rate variation, then the VAT rate dispersion across firms would be greatly reduced by taking the time average. However, this is not supported empirically. This is mainly because the VAT rate of each firm exhibits two salient features over time: strong fixed effect, and persistency.

Fixed effect is captured by τ_i , which is largely inherited from regional and firm's characteristics. Regression results in Table A.1 confirm that about 60% of the fixed effect come from a firm's characteristics in terms of jurisdiction, ownership type, and industry.

Persistency is represented by $AR(1)$ parameter ρ . For firm i , serial correlation coefficient (conditional on i) is $corr_i(\tau_{it}, \tau_{it+1}) = \rho$. Table A.6 reports the correlation coefficient from 2000 to 2007, showing ρ is around 0.6.

Table A.6: Serial Correlation of VAT Rate over Years

Export Refund

One may argue that an export refund could be an important source of VAT rate dispersion, given the fact that firms in China are increasingly more reliant on international markets. The data, however, does not agree with this argument. Table A.7 demonstrates that the export tax refund does not significantly contribute to the VAT rate dispersion, even though it reduces the average VAT rate. The data only provides the VAT rate ex-post refund. I recover the VAT rate ex-ante refund by removing the contribution of tax refund based on the regression of the VAT rate on export.

Table A.7: VAT Rate Dispersions and Export Refund

Entry and Exit of Firm

Quite commonly, the entry and exit of a firm produces massive extensive margins in addition to the existing firms. To check the impact of entry and exit on an average VAT rate dispersion, I categorize the firms into two groups: (1) firms staying in the sample for at least the period from 2000 to 2003 (or at least 2005 to 2007); (2) firms staying for less than three years. Table A.8 reports the difference in VAT rate and within-group standard deviation between Group 1 and Group 2. Group 2 has a significantly lower tax rate but higher dispersion by 1.02%, which is not considered to be a striking difference.

Table A.8: Effect of Entry and Exit of firms on VAT Rate

Correlation with Firm Size

In this paper, I assume that the effective VAT rate is independent of firm size. Although the regression in Table A.1 suggests that the effective VAT rate significantly decreases by 1% if the size of the firm (measured by valued-added) rises by 2.5 times, this effect is quite small and negligible compared to the considerable TFP loss. To further justify this assumption, Table A.9 reports the correlation between VAT rate and firm size, measured in terms of value-added, labour input, and capital input. The results show that the correlation coefficients are quite small and imply that the VAT in China is not a typical “size-dependent policy” suggested by Guner et al. (2008).

Table A.9: Correlation between VAT Rate and Firm Size^a

Appendix 2. Measurement of Human Capital

Human capital measurement is vital to distortion issues, since the distorted wage is measured in the following way:²⁵

$$w_i = w(1 + \tau_i) = \frac{\sigma - 1}{\sigma} \frac{(1 - \alpha)P_i Y_i}{h_i L_i} \quad (\text{A.4})$$

Obviously from Eq. A.4, bad measurement for h_i will be accounted in distortion τ_i .

Hsieh and Klenow (2009) use the firm’s wage bill to proxy human capital and point out that the wage bill in China’s firm survey might be problematic. In the following sections, I propose a method for human capital measurement. I firstly compare the results, at the “industry-province-ownership cell” level rather than the firm level, by using the wage bill as proxy for human capital (as per Hsieh and Klenow (2009)’s approach) and by using the hedonic wage as human capital. We will observe that Hsieh and Klenow (2009) may understate the contribution of labour distortion to TFP loss. I then use a method, based on the hedonic wage, to calculate the human capital for each firm in the firm survey data.

A.2.1 Why Do We Need Hedonic Wage?

To examine the potential risk of using wage bill as proxy for human capital, we need to compare the results between the case that uses the wage bill as proxy for human capital and the case that uses other measurements such as hedonic wage for marginal product value of labour. The hedonic wage can be calculated following the two steps below.

First, in light of the wage regression in labour economics literature, we can run the regression below in the first place:

$$\ln w_j^{p,05} = \alpha + X_j \beta + Z_j \gamma + \varepsilon_i \quad (\text{A.5})$$

where $\ln w_j^{p,05}$ is a logarithm of wage of individual- j in *2005 population census*, the superscript p of $\ln w_j^{p,05}$ implies that the data comes from the “*population census*”, and the

²⁵It should be noted that the term “human capital” used in this paper is a misnomer for “Marginal Product Value of Labour”. Hereby I call it “human capital” just for narrative purpose. In this section, I study how to calculate the marginal product value of labour, rather than the narrowly defined human capital which is usually viewed as the returns to schooling, training, and health. To do this, we need to know the “market return” to workers with certain characteristics, which include the worker’s characteristics, including years of schooling, age, sex, and occupation; and the working firm’s characteristics such as ownership type, location, and industry. In labour economics, the wage regression is a very complicated question. It may suffer serious problems such as ability bias, selection bias, and many others. Moreover, quite a lot of factors that contribute to the wage compensation, such as worker-firm matching quality, externality of human capital (peer effects), are unobservable to econometricians. In this paper, I leave aside these micro-labour concerns, due to the lack of high quality data and because of the macroeconomic nature of our original question.

Table A.10: TFP Loss Caused by Distortions in K and H

superscript 05 indicates the year “2005”, X_j is a vector of individual- j ’s characteristics including years of schooling, age, age², sex, occupation, hukou²⁶, migrant worker. Z_j is a vector of characteristics of firm where individual- j works, including ownership of the firm, location, industry (two-digit). The fitted value for $\ln w_j^p$ can be viewed as the hedonic wage of individual- j .

Second, the hedonic wage in each province, each two-digit industry, and each ownership type can be calculated by taking the conditional average over the individual’s $\ln w_j$.

$$\ln w_{p,i,n}^{p,05} = E(\ln w_j^{p,05} | \text{province } p, \text{ industry } i, \text{ ownership } n) \quad (\text{A.6})$$

$\ln w_{p,i,n}^{p,05}$ is calculated in order to match the wage rates in the firm survey. I collapse the data in STATA by industry, province, and ownership type to get an average hedonic wage rate of each “firm” (cell) in 31 provinces, 39 industries, and 2 types of ownership. Since the cell is not rectangular, we have only 1,860 “firm-cells” rather than 2,418 ($31 \times 39 \times 2$) firms. On average, there are 115 ($=214,318/1,860$) individuals in each “firm”. So the average hedonic wage of each firm is, though not perfect, still quite representative.

With two types of human capital measurements available, we can follow the seven steps described at the beginning of Section 6 and calculate the TFP loss caused by distortions in capital and labour. The results are reported in Table A.10.

From Table A.10, we can see that the distortion in human capital can lead to TFP loss by 13%, greater than the role of physical capital (11%). Due to correlations between the distortions, the three distortions combined reduce TFP by 19%, less than the sum of the individual contributions ($11\% + 13\% = 24\%$).

Table A.10 also reports the TFP loss by using Hsieh and Klenow (2009) method (the wage bill as proxy for human capital). From Table A.10 we can see Hsieh and Klenow (2009) under-estimate the TFP loss by approximately 5%. This is mainly because Hsieh and Klenow (2009) use the wage bill as proxy for human capital. The wage bill in the firm survey has larger dispersion than the true human capital and would attribute the distortions to the variations in human capital. The contribution of distortions to TFP loss, therefore, is understated.

From Table A.10, we are convinced that it is better to use the hedonic wage as a

²⁶Hukou is a household registration record that officially identifies a person as a resident of an area and includes identifying information such as name, parents, spouse, and date of birth. Originally, Hukou as a family registering system was in existence in China as early as the Xia Dynasty (c. 2100 BC - 1600 BC). The current Hukou system was promulgated in 1958 by the Chinese government in order to control the movement of people between urban and rural areas. Individuals were broadly categorized as a “rural” or “urban” residents. People who worked outside their authorized domain or geographical area would not qualify for grain rations, employer-provided housing, or health care. There were controls over education, employment, marriage and so on. (Wikipedia, 2015)

measurement for human capital. But up to now we have simply obtained the hedonic wage for each “industry-province-ownership cell”. In order to calculate the effect of distortions at the firm level, we still need the human capital measurement at the firm level.

A.2.2 Hedonic Wage at the Firm Level

To estimate the hedonic wage as a measurement of human capital at the firm level, I combine the firm survey and the population census in year 2005 and make a statistical inference in the following way.

Firstly, since from the last section we have also known the hedonic wage in each province, each two-digit industry, and each ownership type $\ln w_{p,i,n}^{p,05}$, to find the relationship between the hedonic wage and the wage rate reported in the firm survey, we can regress $\ln w_{p,i,n}^{p,05}$ on $\ln w_{p,i,n}^{f,05}$, where $w_{p,i,n}^{f,05}$ is the average rate in province p , industry i , and ownership n from the “*firm* survey”.

$$\ln w_{p,i,n}^{p,05} = \kappa + \phi \ln w_{p,i,n}^{f,05} + \xi_{p,i} \quad (\text{A.7})$$

based on which we can get the linear projection of the hedonic wage from the wage rate reported in the firm survey.

Second, I assume that relationship between $\ln w_{p,i,n}^{p,05}$ and $\ln w_{p,i,n}^{f,05}$ remains stable across firms and over the firm survey sample periods. Making this assumption, I can calculate the hedonic wage $\hat{w}_{i,t}$ for firm i in year t based on $w_{i,t}^f$, the corresponding reported wage in firm survey, as follows:

$$\hat{w}_{i,t} = \exp(\hat{\kappa} + \hat{\phi} \ln w_{i,t}^f) \quad (\text{A.8})$$

where $\hat{\kappa}$ and $\hat{\phi}$ are estimators of κ and ϕ respectively.

By running OLS on Eq. (A.7), I get $\hat{\kappa} = 8.22(0.032)$, $\hat{\phi} = 0.235(0.0077)$. (The numbers in the brackets are standard deviation) Also, $R^2 = 0.3344$.

With this human capital measurement for each firm, now we can turn to the most important work of this paper — calculating the TFP loss caused by tax distortions.

Table 1: VAT Rate Dispersions within (four-digit) Industries

year	Obs	All Firms ¹	Within Industries ²	Contribution of Within ³
2000	66,200	11.8%	10.5%	97.0%
2001	74,511	11.9%	10.7%	89.4%
2002	83,285	11.0%	10.2%	92.2%
2003	97,993	10.9%	10.1%	90.8%
2004	131,306	11.5%	10.6%	90.6%
2005	129,398	11.3%	10.3%	94.9%
2006	147,696	11.1%	10.2%	95.3%
2007	168,876	10.5%	10.0%	95.1%

Notes:

1. This column lists the standard deviation of the VAT rate across all firms in the Annual Survey of Industrial Production in each year.
2. This column lists the mean taken over 4-digit industries on the within-4-digit-industry standard deviation of VAT rate.
3. This column lists the contribution of within-industry VAT rate variation to the total variation. The results are obtained by variance decomposition through random-effect (GLS) regression. The regression model can be written as: $\tau_{sit} = \tau_t + u_s + e_{it}$, where subscript s is index for 4-digit industry, i for firm, t for year. τ_t is time fixed-effect, u_s is 4-digit industry random effect, e_{it} is firm-year idiosyncratic disturbance. Suppose $var(u_s) = s_u$, $var(e_{it}) = s_e$, and there is no correlation between u_s and e_{it} , then contribution of within-industry variance is measured by $((s_e)/(s_u + s_e))$. In STATA, I use the command: “bysort year: xtreg VAT-rate, i(4-digit-industry code)”. And $((s_e)/(s_u + s_e)) = 1 - \rho$, where ρ can be obtained from running “xtreg”.

Table 2: Summary Statistics – Firm Survey (2000 - 2007) ¹

Variable	Mean	Std.Dev	Min	p1 ²	p50 ²	p99 ²	Max
Capital	108031.6	1450939	1	982	14285	1523384	5.64E+08
Labour	216.1752	949.4027	1	10	82	2183	158288
Value-added	38123.7	462637	4	708	8199	443205	1.63E+08
Wage Bill	14485.27	145675.7	3.6	212.4	3247.2	171399.6	3.02E+07
VAT Rate ³	0.1029848	0.111686	-4.364841	0	0.081578	0.4647059	10.96596

Notes:

1. Sample size = 899,265. There are 66,222 firms in year 2000, 74,511 in year 2001, 83,285 in year 2002, 97,993 in year 2003, 131,306 in year 2004, 129,398 in year 2005, 147,696 in year 2006, 168,876 in year 2007.
2. p1, p50, p99 respectively are 1-*th*, 50-*th*(median), 99-*th* percentile.
3. The (Effective) VAT Rates are calculated by dividing the payable value-added tax by the value-added of each firm.

Table 3: Summary Statistics – Population Census (2005)

Population Census ¹	Mean	Std. Dev.	Min.	Max.
Wage	11830.86	12213.15	12	1199988
Education	9.471699	2.746082	0	19
Age	34.39995	10.33802	18	70

Notes:

1. The data is from 1% sampling Population Census Conducted by the National Bureau of Statistics of China in Year 2005. Sample size = 208,153.

Table 4: Dispersions in VAT and TFP/GDP Loss

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):TFP Loss (%) ¹	58.7	54.5	70.3	72.8	62.6	67.3	67.1	78.5
(2):TFP Loss Net of VAT (%) ²	56.7	52.6	68.2	71.0	59.9	65.4	65.0	75.1
(3):Contribution of VAT (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9
(4):VAT Rate (%) ⁴	10.7	11.0	10.5	10.5	10.3	10.2	10	10.0

Notes:

1. This row is the TFP loss caused by all distortions, with the elasticity of substitution σ equal to 3.
2. This row is the TFP loss caused by all the distortions net of VAT.
3. This row is the contribution of VAT dispersion to the TFP loss, which is equal to $[(1 - \text{TFP Loss Net of VAT}) / (1 - \text{TFP Loss}) - 1] \times 100\%$.
4. This row is the total payable VAT divided by the total value added in the whole manufacturing sector.

Table 5: Correlation between Distortions and Productivity

	$\ln(1 - \tau_{si}^{VAT})$	$\ln(1 + \tau'_{k_{si}})$	$\ln(1 + \tau'_{H_{si}})$	$TFPR_{si}^{KH,1}$	$\ln A_{si}$
$\ln(1 - \tau_{si}^{VAT})$	1.0000				
$\ln(1 + \tau'_{k_{si}})$	-0.0761	1.0000			
$\ln(1 + \tau'_{H_{si}})$	0.1943	0.1503	1.0000		
$TFPR_{si}^{KH,1}$	-0.0009	0.9141	0.4935	1.0000	
$\ln A_{si}$	-0.0255	0.3711	0.6251	0.5079	1.0000
Std. Dev. ²	0.1451	1.6060	1.0398	1.1036	1.3000

Notes:

1. $TFPR_{si}^{KH} = \alpha_s \ln(1 - \tau'_{k_{si}}) + (1 - \alpha_s) \ln(1 - \tau'_{H_{si}})$.
2. This row is standard deviation of variables.

Table 6: TFP Loss with VAT Tax Refund Excluded ¹

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):Contribution of VAT (%) ²	3.0	4.2	9.5	6.6	7.3	6.0	7.8	16.0
(2):Benchmark contribution (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9
(3):VAT Rate net of Refund (%) ⁴	10.8	11.0	10.7	10.6	10.3	10.3	10.2	10.1
(4):Benchmark VAT Rate (%) ⁵	10.7	11.0	10.5	10.5	10.3	10.2	10.0	10.0

Notes:

1. The VAT rate used in this table is the counter-factual VAT rate with export tax refund being excluded.
2. This row is the contribution of VAT dispersion to the TFP loss.
3. This row is the contribution of VAT dispersion to the TFP loss in Table 4 (benchmark).
4. This row is the total payable VAT divided by the total value added in the whole manufacturing sector.
5. This row is the total payable VAT divided by the total value added in the whole manufacturing sector in Table 4 (benchmark).

Table 7: TFP Loss with Time Average of VAT Rate (% , 2000-2003)

Year	2000 ⁵	2001 ⁵	2002 ⁵	2003 ⁵	Year Average ⁶
(1):Sample 1 ¹	1.8	1.9	5.5	1.5	1.5
(1):Sample 2 ²	2.1	2.0	7.4	6.3	2.2
(3):Sample 3 ³	5.6	3.5	7.9	6.8	3.4
(4):Sample 4 ⁴	5.0	4.3	7.3	6.5	4.0

Notes:

1. Sample 1 only includes firms staying over year 2000, 2001, 2002, and 2003.
2. Sample 2 includes firms staying for at least three years in year 2000, 2001, 2002, and 2003.
3. Sample 3 includes firms staying for at least two years in year 2000, 2001, 2002, and 2003.
4. Sample 4 is the full sample.
5. The TFP losses in this column are calculated with corresponding year's effective VAT rate for firms in the corresponding sample.
6. The TFP losses in this column are calculated with the year-average effective VAT rate for firms in the corresponding sample. Firms staying in the sample for three years take the 3-year average of VAT rate. And firms staying for two years take 2-year average. Firms staying for only one year takes its effective VAT rate in that year.

Table 8: TFP loss with Time Average of VAT Rate (% , 2005-2007)

Year	2005 ⁴	2006 ⁴	2007 ⁴	Year Average ⁵
(1):Sample 5 ¹	3.7	4.0	12.6	4.0
(2):Sample 6 ²	3.9	5.3	13.3	4.2
(3):Sample 7 ³	5.7	6.6	15.9	9.2

Notes:

1. Sample 5 only includes firms staying over year 2005, 2006, and 2007.
2. Sample 6 includes firms staying for at least two years in year 2005, 2006, and 2007.
3. Sample 7 is the full sample.
4. The TFP losses in this column are calculated with corresponding year's effective VAT rate for firms in the corresponding sample.
5. The TFP losses in this column are calculated with the year-average effective VAT rate for firms in the corresponding sample. Firms staying in the sample for three years take the 3-year average of VAT rate. And firms staying for two years take 2-year average. Firms staying for only one year takes its effective VAT rate in that year.

Table 9: TFP loss with Checks on Data Quality ¹

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):Contribution of VAT (%) ²	6.8	4.3	3.5	2.7	7.0	4.6	4.5	21.3
(2):Benchmark contribution (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9
(3): VAT Rate (%) ⁴	10.8	11.0	10.5	10.2	9.9	10.2	10.2	10.0
(4):Benchmark VAT Rate (%) ⁵	10.7	11.0	10.5	10.5	10.3	10.2	10.0	10.0

Notes:

1. The sample here only includes the firms in those industries where VAT Tax Burden Ratio lie within the warning bounds issued in 2007 by the National Bureau of Taxation.
2. This row is the contribution of VAT dispersion to the TFP loss.
3. This row is the contribution of VAT dispersion to the TFP loss in Table 4 (benchmark).
4. This row is the total payable VAT divided by the total value added in the whole manufacturing sector.
5. This row is the total payable VAT divided by the total value added in the whole manufacturing sector in Table 4 (benchmark).

Table 10: TFP Loss with Outliers Excluded ¹

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):Contribution of VAT (%) ²	5.0	4.3	7.4	6.6	7.4	5.8	4.4	6.5
(2):Benchmark contribution (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9
(3):VAT Rate (Average, %) ⁴	10.6	10.9	10.5	10.4	10.3	10.1	10.0	9.9
(4):VAT Rate (Min, %) ⁵	-16.8	-23	-25.4	-30	-44.5	-30.7	-31	-28.6
(5):VAT Rate (Max, %) ⁶	100	107.2	100	100	105.8	100.1	98.2	98.9
(6):Benchmark VAT Rate (%) ⁷	10.7	11.0	10.5	10.5	10.3	10.2	10.0	10.0

Notes:

1. The sample here excludes the firms with the effective VAT rates lower than 1-*th* percentile or greater than 99-*th* percentile. 2. This row is the contribution of VAT dispersion to the TFP loss.
3. This row is the contribution of VAT dispersion to the TFP loss in Table 4 (benchmark).
4. This row is the total payable VAT divided by the total value added in the whole manufacturing sector.
5. This row is the firms' minimum effective VAT rate in each year.
6. This row is the firms' maximum effective VAT rate in each year.
7. This row is the total payable VAT divided by the total value added in the whole manufacturing sector in Table 4 (benchmark).

Table 11: TFP Loss with $\sigma = 5$ ¹

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):Contribution of VAT (%) ²	14.8	19.0	26.7	23.5	40.0	34.9	36.7	58.3
(2):Benchmark contribution (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9

Notes:

1. The results in this table are based on calculation with the elasticity of substitution σ equal to 5.
2. This row is the contribution of VAT dispersion to the TFP loss.
3. This row is the contribution of VAT dispersion to the TFP loss in Table 4 (benchmark).

Table 12: TFP Loss with VAT Reform Provinces and Industries Excluded ¹

Year	2000	2001	2002	2003	2004	2005	2006	2007
(1):Contribution of VAT (%) ²	5.8	4.8	7.2	8.5	6.7	5.7	5.2	8.8
(2):Benchmark contribution (%) ³	5.0	4.3	7.4	6.5	7.4	5.7	6.6	15.9
(3):VAT Rate (%) ⁴	11.0	11.3	10.8	10.8	10.5	10.5	10.5	10.4
(4):Benchmark VAT Rate (%) ⁵	10.7	11.0	10.5	10.5	10.3	10.2	10.0	10.0

Notes:

1. The sample here excludes all firms in eight industries AND three north-east provinces under 2004 VAT reform.
2. This row is the contribution of VAT dispersion to the TFP loss.
3. This row is the contribution of VAT dispersion to the TFP loss in Table 4 (benchmark).
4. This row is the total payable VAT divided by the total value added in the whole manufacturing sector.
5. This row is the total payable VAT divided by the total value added in the whole manufacturing sector in Table 4 (benchmark).

Table A.1: Sources of VAT Rate Dispersions

Dependent variable: VAT Rate τ_{it} (%) (Pooled Regression: 2000-2007)					
	(1)	(2)	(3)	(4)	(5)
Constant	10.66 (0.04)***	10.65 (0.05)***	10.78 (0.04)***	10.76 (0.05)***	16.92 (0.18)***
SOE ¹	NO	NO	NO	NO	0.91 (0.10)***
Size of firm ²	NO	NO	NO	NO	-0.71 (0.02)***
Ratio of Value-added ³	NO	NO	NO	NO	-0.04 (0.01)***
Export-Sales Ratio ⁴	NO	NO	NO	NO	-0.38 (0.03)***
# of establishments ⁵	NO	NO	NO	NO	0.01 (0.01)
Year FE ⁶	YES	YES	YES	YES	YES
Industry FE ⁷	NO	YES	NO	NO	NO
County FE ⁸	NO	NO	YES	NO	NO
Indu-County FE ⁹	NO	NO	NO	YES	YES
R^2	0.00	0.06	0.11	0.44	0.55
Sample Size	899,265	899,265	899,265	899,265	374,649

Notes:

1. Dummy for SOE (State-owned-enterprise). SOE = 1 for State-owned-enterprise.
2. Size of a firm is measured by logarithm of its value-added.
3. Ratio of value-added, measured by value-added/(value-added + intermediate input), reflects the extent of a firm's vertical integration over its upstream business and products.
4. Export-sales ratio, measured by exports divided by a firm's sales.
5. Number of establishments within a firm.
6. Control for year fixed effects.
7. Control for (4-digit)industry fixed effects.
8. Control for county fixed effects.
9. Control for (4-digit)industry-county fixed effects.
10. Ordinary least squares. *** (**, *) indicates statistical significance at the 99%(95%, 90%) confidence level.

Table A.2: Determinants of Input VAT Rate

Dependent variable: (Input VAT)/(Intermediate Goods Purchase) (%) (Pooled Regression: 2000-2007)					
	(1)	(2)	(3)	(4)	(5)
Constant	145.15 (42.65)***	184.79 (47.71)***	30.13 (30.72)	44.97 (42.16)	-828.32 (152.51)***
SOE ¹	NO	NO	NO	NO	24.78 (85.09)
Size of firm ²	NO	NO	NO	NO	97.69 (16.61)***
Ratio of Value-added ³	NO	NO	NO	NO	5.6 (6.84)
Export-Sales Ratio ⁴	YES NO	YES YES	YES NO	YES NO	-8.77 (24.56)
# of establishments ⁵	NO NO	NO NO	YES NO	NO YES	-6.73 (10.75)
Year FE ⁶	YES	YES	YES	YES	YES
Industry FE ⁷	NO	YES	NO	NO	NO
County FE ⁸	NO	NO	YES	NO	NO
Indu-County FE ⁹	NO	NO	NO	YES	YES
R^2	0.00	0.00	0.53	0.63	0.79
Observation	898,343	898,343	898,343	898,343	373,987

Notes:

1. Dummy for SOE (State-owned-enterprise). SOE = 1 for State-owned-enterprise.
2. Size of a firm is measured by logarithm of its value-added.
3. Ratio of value-added, measured by value-added/(value-added + intermediate input), reflects the extent of a firm's vertical integration over its upstream business and products.
4. Export-sales ratio, measured by exports divided by a firm's sales.
5. Number of establishments within a firm.
6. Control for year fixed effects.
7. Control for (4-digit)industry fixed effects.
8. Control for county fixed effects.
9. Control for (4-digit)industry-county fixed effects.
10. Ordinary least squares. *** (**, *) indicates statistical significance at the 99%(95%, 90%) confidence level.

Table A.3: Determinants of Output VAT Rate

Dependent variable: (Output VAT)/(Sales Turnover) (%) (Pooled Regression: 2000-2007)					
	(1)	(2)	(3)	(4)	(5)
Constant	10.42 (0.06)***	10.79 (0.07)***	10.57 (0.07)***	10.86 (0.09)***	12.39 (0.18)***
SOE ¹	NO	NO	NO	NO	0.61 (0.10)***
Size of firm ²	NO	NO	NO	NO	-0.41 (0.02)***
Ratio of Value-added ³	NO	NO	NO	NO	5.39 (0.01)***
Export-Sales Ratio ⁴	NO	NO	NO	NO	-0.48 (0.03)***
# of establishments ⁵	NO	NO	NO	NO	0.00 (0.01)
Year FE ⁶	YES	YES	YES	YES	YES
Industry FE ⁷	NO	YES	NO	NO	NO
County FE ⁸	NO	NO	YES	NO	NO
Indu-County FE ⁹	NO	NO	NO	YES	YES
R^2	0.00	0.02	0.04	0.23	0.83
Observation	899,250	899,250	899,250	899,250	374,649

Notes:

1. Dummy for SOE (State-owned-enterprise). SOE = 1 for State-owned-enterprise.
2. Size of a firm is measured by logarithm of its value-added.
3. Ratio of value-added, measured by value-added/(value-added + intermediate input), reflects the extent of a firm's vertical integration over its upstream business and products.
4. Export-sales ratio, measured by exports divided by a firm's sales.
5. Number of establishments within a firm.
6. Control for year fixed effects.
7. Control for (4-digit)industry fixed effects.
8. Control for county fixed effects.
9. Control for (4-digit)industry-county fixed effects.
10. Ordinary least squares. *** (**, *) indicates statistical significance at the 99%(95%, 90%) confidence level.

Table A.4: VAT Rate and Reform – Summary Statistics

	All Provinces		Northeast Provinces ^{1,2}		Other Provinces ³	
year	mean (%)	S.D. (%)	mean (%)	S.D. (%)	mean (%)	S.D. (%)
2000	10.7	11.8	12.0	14.0	10.6	11.6
2000	11.0	11.9	11.0	12.6	11.0	11.9
2002	10.5	11.0	11.1	12.5	10.5	10.9
2003	10.5	10.9	10.7	13.8	10.4	10.7
2004	10.3	11.5	10.8	14.4	10.3	11.2
2005	10.2	11.3	9.0	14.1	10.3	11.1
2006	10.0	11.1	8.0	11.8	10.2	11.0
2007	10.0	10.5	8.0	10.1	10.1	10.5

Notes:

1. Northeast provinces include Jilin, Liaoning, and Heilongjiang.
2. Consumption-type VAT was only applicable in six selected industries, including agricultural product processing, equipment manufacturing, petrochemical, metallurgy, ship building, automobile manufacturing, military products and high-tech products.
3. In July of 2007, the reform was extended to another twenty-six cities in six central-region provinces. In this column these cities are not dropped from "Other Provinces" due to very short sample period (only 6 months).

Table A.5: VAT Rate (%) and Reform – Regression ¹

	τ_{it}	$Std(\tau_{it})$
	(1)	(2)
$R_i^{NE} I_i^s Y_t^{After}$	-0.76 (0.60)	-1.25 (0.58)**
$R_i^{NE} Y_t^{After}$	-2.21 (0.41)***	-0.32 (0.19)*
$I_i^s Y_t^{After}$	0.49 (0.29)*	0.29 (0.19)
$R_i^{NE} I_i^s$	-0.05 (1.21)	1.85 (0.82)**
$R_i^{NE,2}$	0.62 (0.46)	0.61 (0.23)***
$I_i^{s,3}$	-1.36 (0.54)**	0.44 (0.19)**
$Y_t^{After,4}$	-0.39 (0.14)***	-0.81 (0.07)***
Constant	10.85 (0.20)***	7.3 (0.08)***
R^2	0.00	0.01
Observation	899,265	69,148

Notes:

1. The regression is based on triple difference (Equation (A.3)) - between regions, between industries, over time periods - driven by the consumption-type VAT reform in Northeast provinces in 2004. τ_{it} is the effective VAT rate at firm level. $Std(\tau_{it})$ is the standard-deviation of τ_{it} within (2-digit)industry-province cells.
2. Regional dummy R_i^{NE} for Northeast provinces, including Jilin, Liaoning, and Heilongjiang.
3. Industrial dummy I_i^s for six industries under consumption-type VAT reform, including agricultural product processing, equipment manufacturing, petrochemical, metallurgy, ship building, automobile manufacturing, military products and high-tech products.
4. Time dummy Y_t^{After} for years post reform (after January of 2005). In July of 2007, the reform was extended to another twenty-six cities in six central-region provinces, which are not taken into account due to very short sample period (only 6 months).
5. Ordinary least squares. *** (**, *) indicates statistical significance at the 99%(95%, 90%) confidence level. Robust standard errors are clustered at the (2-digit)industry-province level (1,177 groups).

Table A.6: Serial Correlation of VAT Rate over Years

	Sample 1 ¹		Sample 2 ²	
	2001-2002	2002-2003	2005-2006	2006-2007
Firm Level	0.53	0.62	0.60	0.60
County Level	0.78	0.80	0.81	0.83
City Level	0.89	0.89	0.90	0.92
Province Level	0.96	0.97	0.96	0.97
4-digit Industry Level	0.77	0.49	0.90	0.75
2-digit Industry	0.97	0.95	0.99	0.99

Notes:

1. Because of the change in firm ID, we can not link the firms before 2004 to firms thereafter. Year 2004 is not included due to inconsistency of firm ID. Sample 1 only includes the firms staying in the survey for 2001, 2002, and 2003 period. The sample size is 50,236. Year 2000 is not included so that Sample 1 and 2 are both comparably three years.
2. Sample 2 only includes the firms staying in the firm survey for 2005, 2006, 2007 period. The sample size is 66,345.

Table A.7: VAT Rate Dispersions and Export Refund

year	Ex-post Refund ¹		Ex-ante Refund ²	
	mean (%)	S.D. (%)	mean (%)	S.D. (%)
2000	10.7	11.8	10.8	11.8
2001	11.0	11.9	11.1	12.0
2002	10.5	11.0	10.7	11.0
2003	10.5	10.9	10.6	10.9
2004	10.3	11.5	10.4	11.4
2005	10.2	11.3	10.3	11.3
2006	10.0	11.1	10.2	11.1
2007	10.0	10.5	10.1	10.5

Notes:

1. This column lists the mean and standard deviation of the effective VAT rates in the Annual Survey of Industrial Production.
2. This column lists the mean and standard deviation of the counter-factual VAT rates with export refund not being conducted. To get the counter-factual VAT rates, I run the following regression: $VAT_rate = \alpha + \beta * (Export/VA) + \gamma * X + \epsilon$, where *Export* is firm's export value, *VA* is firm's value-added, and *X* are a vector of firm's characteristics, including county, 4-digit industry, and ownership type. The counter-factual VAT rate is equal to "Effective VAT rate $-\hat{\beta} * (Export/VA)$ " where $\hat{\beta}$ is estimator for β .

Table A.8: Effect of Entry and Exit of firms on VAT Rate

Dependent Variable ¹	
$Ave_ \tau_{st}^{G2} - Ave_ \tau_{st}^{G1} (\%)^2$	$Std_ \tau_{st}^{G2} - Std_ \tau_{st}^{G1} (\%)^3$
-0.13* ⁴	1.02*** ⁴
(-1.68)	(9.88)

Notes:

1. A dependent variable is regressed on a constant, which indicates the gap between the Group 1 and the Group 2.
2. $Ave_ \tau_{st}^{Gi}$ is the average of VAT rate over firms of group i in industry s in year t .
3. $Std_ \tau_{st}^{Gi}$ is the standard deviation of VAT rate over firms of group i in industry s in year t .
4. Estimated constant. *** (**, *) indicates statistical significance at the 99%(95%, 90%) confidence level.

Table A.9: Correlation between VAT Rate and Firm Size ¹

Value-added	Capital	Labor	ln(Value-added)	ln(Capital)	ln(Labor)
0.0079	0.0221	0.0184	-0.0225	0.0962	0.029

Notes:

1. Size of a firm is measured respectively by its value-added, capital stock, number of employee, and their logarithm, including year 2000, 2001, 2002, 2003, 2005, 2006, 2007.

Table A.10: TFP Loss Caused by Distortions in K and H ¹

Distortions	K	H	(K, H)
TFP Loss (% , Chen(15) method ²)	11	13	19
TFP Loss (% , HK(09) method ³)	11	9	14

Notes:

1. To make comparison, the TFP loss is calculated based on the “industry-province-ownership cell”, rather than the real firms in firm survey. There are thirty-nine 2-digit industries, thirty-one provinces, and two types of firm ownership (SOE, and Non-SOE) and 1,860 cells in our sample.
2. Chen(15) method uses hedonic wage as the proxy for human capital for each “industry-province-ownership cell”.
3. HK(09) method uses wage bill as the proxy for human capital for each “industry-province-ownership cell”.

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