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Resource Misallocation and Regional Policy in China

Lihua Xu
School of Economics, University of the Thai Chamber of Commerce, Bangkok, Thailand
Corresponding author: xuhan3434@hotmail.com

Abstract

The research presents a monopolistic competition model with heterogeneous firms to measure resource misallocation across regions and sectors in China. This paper investigates the role of a reduction of the corporate income tax rate and value-added tax reform on productivity and resource misallocation. Micro-data from Chinese manufacturing enterprises in 1998-2007 are used. The results show that overall resource misallocation increased after 2000. Resource misallocation increased faster in the Northeast and Southwest regions, where preferential policies were applied. Moreover, physical and revenue productivity were promoted by the reduction of corporate income tax and value-added tax reform. The results show that the reduction of the corporate income tax intensifies resource misallocation. However, the value-added tax reform has no effect on resource misallocation.

Keywords: Total Factor Productivity, Resource Misallocation, Regional Policy, Heterogeneous Firms

Introduction

The efficiency of resource allocation is important to total factor productivity (TFP) growth. To estimate the underlying resources of TFP differences across countries and industries, recently much literature has focused on the misallocation of resources (Restuccia & Rogerson, 2008; Hsieh & Klenow, 2009; Banerjee & Moll, 2010).

The efficiency of resource allocation has played a great role in TFP growth in China over the past three decades (Yi, Fang, & Li, 2003). After economic reform, restriction of labor mobility and obstacles in the financial system were significantly relaxed (Holz, 2009; Holz, in press). Thus, some of the rapid growth that China has enjoyed during the past three-and-a-half decades has likely come from reductions in distortions as a result of economic reform (Brandt, 2013).

However, regional policies in China after economic reform are regarded as important, underlying resources of misallocation (World Bank, 2013). After 1999, the Chinese central government began to exercise considerable influence on resource allocation through a series of preferential policies. Thus, this paper brings forth an issue for discussion: what is the impact of regional policies on resource allocation and aggregate TFP across regions in China?

An influential paper authored by Hsieh and Klenow (2009) developed a monopolistic framework with heterogeneous firms to measure misallocation quantitatively. They argued that if resource allocation in China were efficient, the TFP of China's manufacturing industry could increase between 86% and 115% during the period 1998-2005.

Based on Hsieh and Klenow's model, several papers estimate resource misallocation and TFP growth in China's manufacturing industry. Brandt, Tombe, and Zhu (2013), Gong and Hu (2013), Li, Peng, and Mao (2013), and Shao, Bu, and Zhang (2013) found that misallocation differs across regions, sectors, state-owned enterprises (SOEs), non-SOEs, exporting firms and non-exporting firms. They stated that TFP among industrial enterprises would increase if the enterprises could effectively wipe out distortions. Furthermore, a large body of literature evaluates the effect of preferential policies on economic growth rather than on resource misallocation. For example, Liu and

Qiu (2006) argued that preferential corporate income tax policies in Western economies have had significant, positive effects on their growth by promoting the profitability of firms. Yang, Cao, and Du (2013) argued that a reduction of the corporate income tax rate has a positive effect on R&D. Nie, Fang, and Li (2009) used Chinese manufacturing enterprise data from 1999 to 2005 to evaluate the policy effects of value-added tax (VAT) reform in the Northeast region that was effected in 2004. They found that VAT reform significantly promoted investment in acquiring fixed assets, increasing labor productivity, and promoting R&D. Such studies are rarely conducted in evaluating regional policies toward resource misallocation in China. Jiang (2016) found that VAT reform reduces productivity dispersion and resource misallocation. However, Jiang's proxy of resource misallocation differs from that in this research.

With this background in mind, by following the accounting procedures of Hsieh and Klenow (2009), this paper measures the efficiency of resource allocation across six regions[1] in China: the Northeast, Southeast, Central, Southwest, Northwest and the Bohai coastal region. Specifically, we relate the gaps of distortion across regions to explicit government policies. We take a reduction of the corporate income tax rate from 33% to 15% as well as VAT reform as examples. This paper uses the "natural experiment" of difference-in-difference estimation to explore the effects of policy interventions by comparing the difference in outcomes before and after the intervention for treatment groups with the outcome differences for control groups.

The contributions of this paper are threefold. We first provide results concerning resource misallocation across six regions in China by following Hsieh and Klenow's method. Second, this research used firm-level data of Chinese manufacturing enterprises for the period 1998-2007 to estimate the effect of preferential policy on productivity among heterogeneous firms. Our third contribution is that we evaluate the effect of corporate income tax and VAT reform on resource misallocation by creating a panel dataset at the sector level.

[1] Classification follows the Development Research Center of the State Council and The World Bank (2013).

The results show that overall resource misallocation increased after 2000. Resource misallocation increased faster in the Northeast and Southwest regions, where preferential policies were applied. Moreover, physical and revenue productivity were promoted by the reduction of the corporate income tax and value-added tax reform. The reduction of corporate income tax intensified the resource misallocation. However, VAT reform had no effect on resource misallocation. Despite the contribution of preferential policy to economic growth, this research presents some policy implications. The increasing resource misallocation by the reduction of corporate income tax must attract attention in Western. Policies should focus on innovation and not only on investment. The policy should consider the heterogeneities of firms, remove the protection of SOEs, and encourage the growth of foreign-owned firms and non-SOEs. The scope of government-encouraged sectors should be expanded to address the increasing resource misallocation.

The remainder of this paper is as follows. In next section, we present Hsieh and Klenow's model. Section 3 discusses the data, sampling and some approaches to rearranging the data. Section 4 summarizes the corporate income tax and VAT reform. Section 5 presents the results of the evolution of resource misallocation. Section 6 evaluates the effect of preferential policies on productivity and resource misallocation. Section7 concludes the paper.

2. Model

In this section, we present a model to show the relationship between resource misallocation and aggregate productivity allowing for firm-level heterogeneity as studied by Hsieh and Klenow (2009).

Consider an economy consisting of s sectors, with the benchmark economy as a perfectly competitive market, and aggregate output defined as follows:

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

where Y is the output of final goods, Y_s is the intermediate goods from sector s with expenditure shares θ_s that total one.

The problem of minimizing the cost for the final goods is shown as follows:

$$C(Y) = min \sum_{s=1}^{S} P_s Y_s, \; s.t: \; \prod_{s=1}^{S} Y_s^{\theta_s} \geq Y \tag{2}$$

The first-order condition yields $P_s Y_s = \theta_s PY$, where P_s is the price of intermediate goods Y_s, P is the price of the final goods (normalized to 1); and Y_s has a CES aggregate production function given by M_s differentiated products.

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1 \tag{3}$$

Y_{si} is the real output from firm i in sector s; M_s is the number of firms in sector s; and we assume Cobb-Douglas production technology in a monopolistic competition market.

$$Y_{si} = A_{si} K_{si}^{\alpha_s} L_{si}^{1-\alpha_s} \; 0 < \alpha_s < 1 \text{ for each } s = 1, \ldots, S \tag{4}$$

where A_{si} is TFP for each firm; K_{si} and L_{si} are capital input and labor input respectively; and α_s is the capital share of sector s.

With the above background, solving the first-order condition for the cost minimization problem in monopolistically competitive producers within each industry yields, $P_s \left(\frac{Y_s}{Y_{si}} \right)^{\frac{1}{\sigma}} = P_{si}$, where P_{si} is the price for differentiated goods and is defined as $P_s = \left(\sum_{i=1}^{M_s} P_{si}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$.

One measure of TFP is the difference in "physical productivity" (TFPQ) across firms, which is given by:

$$TFPQ_{si} = A_{si} \tag{5}$$

However, what we could estimate is not TFPQ, since the output is unobserved. We could estimate "revenue productivity" (TFPR). The TFPR is measured as:

$$TFPR_{si} = P_{si} A_{si} = \frac{P_{si} Y_{si}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}} \tag{6}$$

If there are no firm specific distortions and all firms within a sector have the same markup, TFPR will be equalized across firms within a sector. In general, the variation of TFPR within a sector will be a measure of misallocation.

Hsieh and Klenow (2009) assume that firm-specific wedges affect total production and capital, essentially modeled as output distortion τ_{Ysi} and capital distortion $\tau_{Ksi.}$ As a result of these wedges, firms produce different amounts of output than what would be dictated by their productivity, and they may also have different capital-labor ratios.

Profit for an individual firm is:

$$\pi_{si} = (1 - \tau_{Ysi})P_{si}Y_{si} - wL_{si} - (1 + \tau_{Ksi})RK_{si} \tag{7}$$

We solve the maximization problem by choosing L_{si}, K_{si}, which yields:

$$L_{si} = \frac{\sigma-1}{\sigma}\frac{1-\alpha_s}{w}(1 - \tau_{Ysi})P_{si}Y_{si} \tag{8}$$

$$K_{si} = \frac{\sigma-1}{\sigma}\frac{\alpha_s}{R}\frac{1-\tau_{Ysi}}{1+\tau_{Ksi}}P_{si}Y_{si} \tag{9}$$

$$\frac{K_{si}}{L_{si}} = \frac{w}{R}.\frac{\alpha_s}{1-\alpha_s}.\frac{1}{1+\tau_{Ksi}} \tag{10}$$

From above, we know that resource allocation depends on output and capital distortions that firms face. Distortions will lead to differences in the marginal revenue products of labor and capital across firms, and those differences lead to variations of in TFPR. For example, high TFPQ firms will produce less than they would if they had faced disincentives that resulted in higher TFPR. Low TFPQ firms will produce more than they would if they had benefited from subsidies that resulted in lower TFPR.

Rearranging equations (8) and (9), we infer the distortion for each firm in each year as follows:

$$1 + \tau_{K_{si}} = \frac{\alpha_s}{1-\alpha_s}.\frac{wL_{si}}{RK_{si}} \tag{11}$$

$$1 - \tau_{Y_{si}} = \frac{\sigma}{\sigma-1}.\frac{wL_{si}}{(1-\alpha_s)P_{si}Y_{si}} \tag{12}$$

Summing input demands over firms yields the total stock of capital (K_s) and amount of labor (L_s) used in sector *s,*

$$L_S = \sum_{i=1}^{M_S} L_{si} = \frac{\sigma-1}{\sigma}.\frac{1-\alpha_S}{w}\sum_{i=1}^{M_S}(1-\tau_{Ysi})P_{si}Y_{si} \tag{13}$$

$$K_S = \sum_{i=1}^{M_S} K_{si} = \frac{\sigma-1}{\sigma}.\frac{\alpha_S}{R}\sum_{i=1}^{M_S}\frac{1-\tau_{Ysi}}{1+\tau_{Ksi}}P_{si}Y_{si} \tag{14}$$

From L_s and K_s, we get the TFPR in each sector as a function of distortion. Based on the TFPR in each sector, we can derive the expression for aggregate productivity as a function shown below:

$$TFP_S = \left[\sum_{\mathrm{i=1}}^{\mathrm{M_S}}\left(\mathrm{A_{si}}.\frac{\overline{TFPR_S}}{\mathrm{TFPR_{si}}}\right)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{15}$$

If there is no distortion across firms, it implies that marginal products would be equalized across firms and the aggregate TFP would be:

$$\bar{A}_S = \left[\sum_{\mathrm{i=1}}^{\mathrm{M_S}}(\mathrm{A_{si}})^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{16}$$

We treat the output level as efficient if there is no distortion, and to see this we write the final good *Y* as:

$$Y = \prod_{s=1}^{S}\left(TFP_S \cdot K_s^{\alpha_s}\ L_s^{1-\alpha_s}\right)^{\theta_s} \tag{17}$$

As we know, if high TFPQ firms are held back by policy distortions, such firms may choose to restrict production because their output is "inefficient."We define the efficient output as the output if marginal products were equalized across firms in a given industry. We use the ratio of efficient output to inefficient output to measure the gain if the resource misallocation were removed. The ratio of actual aggregate output to efficient aggregate output is given by:

$$\frac{Y}{Y_{efficient}} = \prod_{s=1}^{S}\left[\sum_{i=1}^{M_S}\left(\frac{A_{si}}{\bar{A}_S}\frac{\overline{TFPR_S}}{TFPR_{si}}\right)^{(\sigma-1)}\right]^{\theta_S/(\sigma-1)} \tag{18}$$

The potential gain is given by:

$$G = 100\left(\frac{Y_{efficient}}{Y} - 1\right) \tag{19}$$

It means that the distortion is bigger if the potential gain is bigger.

3. Data

The Chinese firm data came from the Chinese Manufacturing Enterprises Annual Database (CMED), which is based on data from the Chinese Statistics Bureau. It includes all non-SOEs with more than 5 million CNY in annual revenue plus all SOEs for the period 1998-2007.

The variables chosen from the CMED are total wage payments, welfare payments, value-added, capital stock, province code, industrial code[2], registration type, founding year, export value, sales value, and gross output. The definition of each variable is shown in Appendix I. Gross output, value-added, and sales values are deflated by ex-factory price indices in the Industrial Products Index[3]. Capital stock is deflated by investment in the Fixed Assets Price Index. Wages and welfare payments are deflated by the Consumer Price Index. All deflators come from the "China Compendium of Statistics 1949-2008." All deflators are based on an index of 1998=100.

Table 1 provides the descriptive statistics of the underlying data set. The data consist of over 52,000 firms in 1998 and grow to more than 300,000 firms in 2007. Pooling all firms between1998 and 2007 renders 1,722,501 observations.

We adopt U.S labor shares as the benchmark because we assume that the United States data are relatively undistorted. Those shares come from the NBER Productivity Database. This dataset does not provide non-wage compensation such as Social Security payments and other benefits. The

[2] Chinese industrial codes (GB/T 4754-2002) are 481 sectors at the four-digit level and 28 sectors at the two-digit level.

[3] The index comes from the National Bureau of Statistics of China, which reflects the trend and degree of changes in general ex-factory prices of all industrial products. It is equal to (gross industrial output index / gross industrial production index) ×100.

manufacturing labor share in this dataset is about two-thirds of aggregate labor share in manufacturing as calculated by national income and product accounts. Following Hsieh and Klenow (2009), we scale up the labor share 3/2 from the NBER productivity database to arrive at the U.S. labor elasticity for each industry.

Table 1: Summary statistics on data sample in manufacturing sector 1998-2007

(Samples: 1,722,501)

Variables		Characteristics of firms	
Value added	19,304,690	Firm age (year)	13.307 (66.19)
Capital stock	22,151,470	Capital labor ratio	6.721 (58.04)
Sales value	71,154,010	Wage per worker	16,415 (233.72)
Wage payments	3,534,130	HHI	0.004 (0.01)
Welfare	593,050	Fraction of State-owned enterprises	0.22 (0.41)
		Fraction of Exporting firms	0.37 (0.48)
		Fraction of Foreign-owned firms	0.21 (0.41)

Note: Entries are mean values for1998-2007.The mean is calculated after dropping all negative signs, which have a value of CNY. Standard deviations are in parentheses.

The median of labor share in plant-level data is roughly 26%, which is basically lower than the aggregate labor share in manufacturing reported in the Chinese input-output tables and the national accounts (roughly 50%). We therefore accept as true that nonwage benefits are a constant fraction of a firm's wage compensation, where by the adjustment factor is calculated by summing imputed benefits and wages across all plants that equal 50% of aggregate value-added.

For our computations, we drop observations whose wage is zero or negative, employee count is fewer than 10, and gross output, value-added and capital stock are zero or negative. We also trim 1% tails of $log\ (\frac{\overline{TFPR_s}}{TFPR_{si}})$ and $log\ (\frac{A_{si}}{\overline{A_s}})$ in each year to make the results robust to outliers.

We create a panel data set at the sector level by calculating the TFP efficiency gain for each four-digit industry. Industry average plant age, industry fraction of SOEs, industry fraction of foreign investment enterprises, and industry fraction of number of exporting firms are calculated by average firm age, fraction of total number of SOEs, fraction of number of foreign investment enterprises, and across all individual observations within each sector. Definitions of variables in sectors are shown in Appendix II.

4. Chinese regional policy

To promote the development of underdeveloped regions and reduce regional disparities, in 1999, the Chinese central government implemented a series of regional policies. Two important policies that greatly influenced the Western and Northeast regional economics are explained below.

4.1 Reduction of corporate income tax rate

The State Development and Reform Commision and Ministry of Commerce (2000) implemented a preferential corporate income tax rate in the Western region. For domestic and foreign-funded enterprises in Western China that belonged to the category of government-encouraged sectors, a reduced corporate income tax rate of 15% existed from 2001 to 2010, compared with a corporate tax rate of 33% in other regions. The policy was applied to 12 provinces in Western China (hereafter referred to as "Western"). However, the problem is we were unable to identify firms that benefited from the preferential policy because not all firms in these promoted sectors benefit the special corporate income tax.

Table 2 shows the summary statistics between the treatment and control group before and after the rate reduction in the corporate income tax. It is obvious that output, sales value, and profitability increased more in Western than in other regions after 2001.

Table 2: Comparison between Western and other regions

Variables	1998-2000			2001-2007		
	Western (1)	Other (2)	Difference (3)=(2)-(1)	Western (4)	Other (5)	Difference (6)=(5)-(4)
Output	13,155	13,624	469	27,393	20,787	-6,606
Capital labor share	9.73	7.87	-1.86	8.55	5.94	-2.61
Sales value	43,232	52,169	8,936	82,943	78,102	-4,841
Sales per worker	221	464	243	286	363	76
Wage rate	9.53	19.54	10.01	13.26	16.02	2.77
Profitability	-0.09	0.05	0.14	0.01	0.03	0.02
SOEs (%)	63	46	-17	21	11	-10
Foreign (%)	6	21	16	7	24	17
Exporting (%)	9	29	20	25	43	18

Note: Entries shown are mean. The k/l is the ratio of capital to labor; Sales is the sales value per worker; Wage is the wage per worker; SOEs is the fraction of the total number of SOEs; Exporting is the fraction of the total number of exporting firms; and Foreign is the fraction of the total number of foreign firms. Profitability= profit/sales value.

4.2 Value-added tax reform

There form of VAT through expanding its levying scope in China was conducted over a 10-year period (1994-2004).To keep pace with economic development, the State Council selected several industries in the Northeast region as a pilot to extend the VAT credit scope beginning on July 1, 2004. As defined by the Ministry of Finance and State Administration of Taxation (2004), the Northeast refers to the provinces of Liaoning, Jilin, and Heilongjiang as well as Dalian city. Industries there have engaged mainly in equipment manufacturing, petrochemicals, metallurgy, ship-building, automobile manufacturing and agro-product processing. Input taxes were allowed to be deducted from purchasing fixed assets, goods purchasing and taxable labor used for company-built fixed assets, transport charges for those fixed assets, and fixed assets obtained through leasing in those industries. However, five sectors were not involved in the reform. In 2007,VAT reform was implemented across six provinces in Central China and 26 cities of old industrial bases, and it was extended to eastern Inner Mongolia in 2008. VAT reform was applied throughout the country in January 2009.

Table 3 compares the characteristics of firms between the treatment and control group before and after VAT reform in the Northeast. It shows that the fractions of the total number of SOEs decreased significantly after 2004 for the whole country. Profitability and sales value increased more in the Northeast than in other regions after 2004.

Table 3: Comparison between the Northeast and other regions

Variables	1998-2003			2004-2007		
	Northeast (1)	Other (2)	Difference (3)=(2)-(1)	Northeast (4)	Other (5)	Difference (6)=(5)-(4)
Output	22,253	16,275	-5,978	27,746	22,661	-5,085
Capital labor share	12.23	7.4	-4.83	8.96	5.17	-3.79
Sales value	82,020	58,437	-23,583	99,884	85,707	-14,177
Sales per worker	346	353	7	453	404	-49
Wage rate	11.01	15.71	4.7	15.91	17.8	1.89
Profitability	-0.05	0.03	0.08	0.03	0.04	0.01
SOEs (%)	43	32	-11	13	7	-6
Foreign (%)	17	21	4	17	22	5
Exporting (%)	38	45	7	17	30	13

Note: Entries shown are mean. The k/l is the ratio of capital and labor; Sales is the sales value per worker; Wages is the wage per worker; SOEs is the fraction of the total number of SOEs; Exporting is the fraction of the total number of exporting firms; and Foreign is the fraction of the total number of foreign firms. Profitability= profit/sales value.

5. Results of resource misallocation

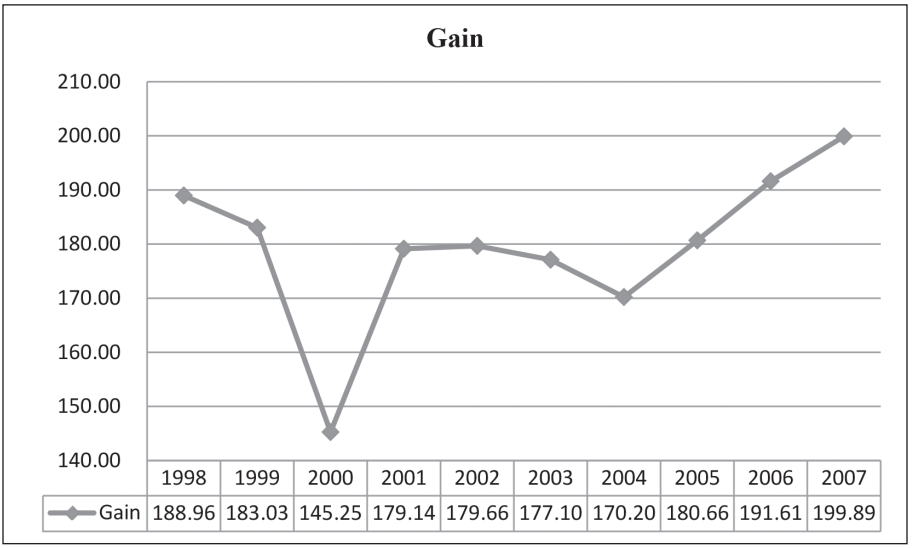
This section presents the results of overall misallocation and misallocation across regions. We use TFP gains by equalizing the TFPR across firms to represent the extent of resource misallocation. That means the higher the TFP gain, the higher the distortion of resource allocation.

5.1 Overall resource misallocation

Figure 1 shows the misallocation in 1998-2007. An initial decline is followed by an upward trend that leads to a higher misallocation in 2006 than in 1998. This means resource misallocation was worse after 2006 than in

1998. Young's (2000) findings show that the initial market reform may have brought about more distortion. The distortion comes from interregional competition that resulted from regional preferential policies which led local governments to impose trade protection measures against each other. The intervention from preferential policies addressed by the Western development strategy implemented in 2000 and the strategy of revitalizing the Northeast industrial base implemented in 2003 might be two sources of this greater misallocation.

Figure 1. The variation of overall misallocation in 1998-2007



	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Gain	188.96	183.03	145.25	179.14	179.66	177.10	170.20	180.66	191.61	199.89

Note: Following Hsieh and Klenow (2009), TFP efficiency gains are calculated by equations (18) and (19).

In 2000, resource misallocation dropped significantly, perhaps from improving productivity through Western's promotion of investment. Since 2000, national fiscal funds and national bonds tended to favor Western; the state budget share for the Western region also increased annually and was much greater than that of other regions. Investment focus included infrastructure construction and rural development (Zheng, 2004). Aschauer (1989) argued that the development of infrastructure significantly promoted productivity growth. Shao et al. (2013) also found that infrastructure can improve resource allocation, perhaps because an enormous investment in infrastructure creates

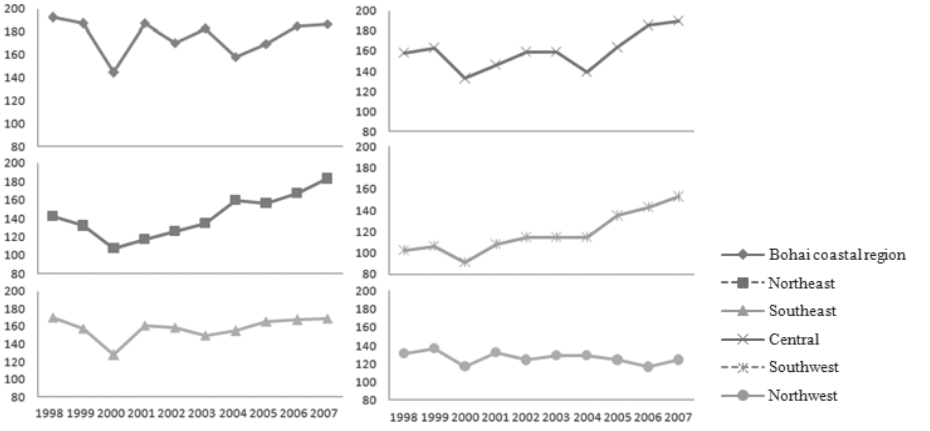
employment opportunities that have a large multiplier effect from its large economies of scale. The drop in resource misallocation comes from the development of infrastructure, whereas the increasing misallocation after 2000 means that misallocation exceeded the benefit of infrastructure development.

5.2 Resource misallocation across regions

Figure 2 shows the time series evolution of resource misallocation in 1998-2007 across six regions. We see distortions increasing after 2000 in all regions except Northwest. The slopes of Northeast and Southwest are steeper than in other regions after 2000, meaning that misallocation increases more than in other regions. It shows that distortion is higher in developed regions such as the Bohai coastal region, Southeast and Central, but lower in underdeveloped regions such as Northwest and Southwest.

From above, one can conclude that overall misallocations worsen with economic growth, and while distortion in the Northeast and Southwest increases faster than in other regions, distortion in the Northwest trends downward. The reasons for this and the mechanism of misallocation are unclear empirically.

Figure 2. The evolution of misallocation across regions



Note: The value is the gain for each region.

6. The incidence of corporate income tax and VAT reform

Since policies play an important role in firms' decision-making processes, in this section we estimate the effects of specific policies on productivity and resource misallocation.

6.1 The effect of regional policy on productivity at the firm level

This study estimates the impact of corporate income tax and VAT reform on TFPQ and TFPR at the firm-level data.

6.1.1 The effect of corporate income tax on productivity

The estimated specification of general form for estimating the effect of corporate income tax is:

$$Productivity_{sit} = \alpha_0 + \alpha_1 X_{sit} + \alpha_2 D_w + \alpha_3 D_{t>2001} + \alpha_4 (D_w \times D_{t>2001}) + \varepsilon_{sit} \quad (20)$$

where i indexes firms, s indexes four-digit sectors, and t indexes years. Productivity means $log\ (TFPQ_{sit})$ *or* $log\ (TFPR_{sit})$; D_w is a region dummy coded 1 for 12 provinces in Western that benefit from preferential policies. $D_{t>2001}$ is a time dummy coded 1 for years after 2001. X_{sit} is a set of control variables that represent characteristics of firm i in sector s in each year t. It includes firm age, dummy for state-owned firms, dummy for foreign firms and dummy for exporting firms.

For the results of the estimation show in table 4, columns (1) and (2) show the effect of the corporate income tax on TFPQ, and columns (3) and (4) show the effect of the corporate income tax on TFPR. The result presents the estimation of equation (20). Columns (2) and (4) are robustness checks with region and year dummies, with results that are robust.

The coefficients of interaction terms are positive and significant. The coefficient of the interaction term is 0.45-0.46 for TFPQ and 0.25-0.28 for TFPR, indicating that preferential corporate income tax rates promote TFPQ and TFPR in Western. The negative coefficients of Western dummies show that TFPQ/TFPR is smaller in Western than in other regions. Combined with coefficients of interaction terms, we conclude that the differences of TFPR (TFPQ) between Western and other regions become smaller after policy implementation.

Table 4: The effect of corporate income on TFPQ and TFPR

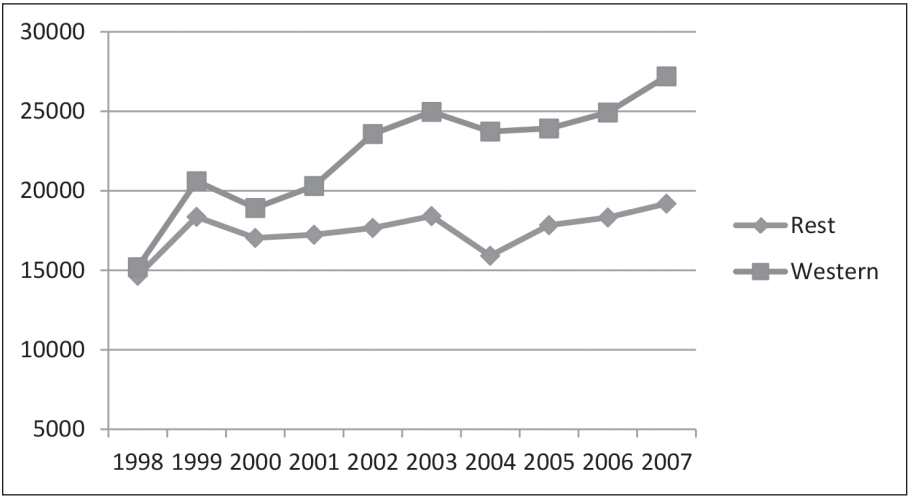
Variables	Log (TFPQ)		Log (TFPR)	
	(1)	(2)	(3)	(4)
$D_w \times D_{t>2001}$	0.4537***	0.4629***	0.2453***	0.2752***
	(0.0071)	(0.0064)	(0.0050)	(0.0045)
Log (age)	-0.0522***	-0.0526***	-0.1520***	-0.1450***
	(0.0014)	(0.0014)	(0.0010)	(0.0010)
D_trade	0.0130***	0.1322***	-0.1204***	-0.1308***
	(0.0023)	(0.0027)	(0.0016)	(0.0019)
D_state	-0.3595***	-0.3317***	-0.1567***	-0.1529***
	(0.0029)	(0.0030)	(0.0021)	(0.0021)
D_foreign	0.0234***	0.0288***	-0.2047***	-0.1815***
	(0.0027)	(0.0027)	(0.0019)	(0.0019)
D_2001	0.4491***		0.2843***	
	(0.0026)		(0.0018)	
D_west	-0.4942***		-0.3279***	
	(0.0060)		(0.0042)	
D_Region	No	Yes	No	Yes
D_Year	No	Yes	No	Yes
D_Sector	Yes	Yes	Yes	Yes
N	**1,722,501**	**1,722,501**	**1,722,501**	**1,722,501**

Note: Robust standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All the regressions control for four-digit 481 sectors in manufacturing industries. D_year refers to 10 years of dummies from 1998 to 2007. D_region refers to six region dummies.

Two reasons may explain why the reduction of corporate income tax promotes TFPQ. First, the reform allocates more investment to Western than to other regions. Investment in machinery and equipment with the latest technology leads to productivity improvement. Figure 3 shows the change of total investment between Western and the other regions over time. The change in total investment is much more in Western than in other regions. Total investment increases significantly in Western, especially after 2001. Table 5

shows the regression of ln (k/l) (capital-labor ratio) on the characteristic of firms. The coefficient of Western dummy is positive and significant, which means the firms in Western are more capital-intensive compared with other regions.

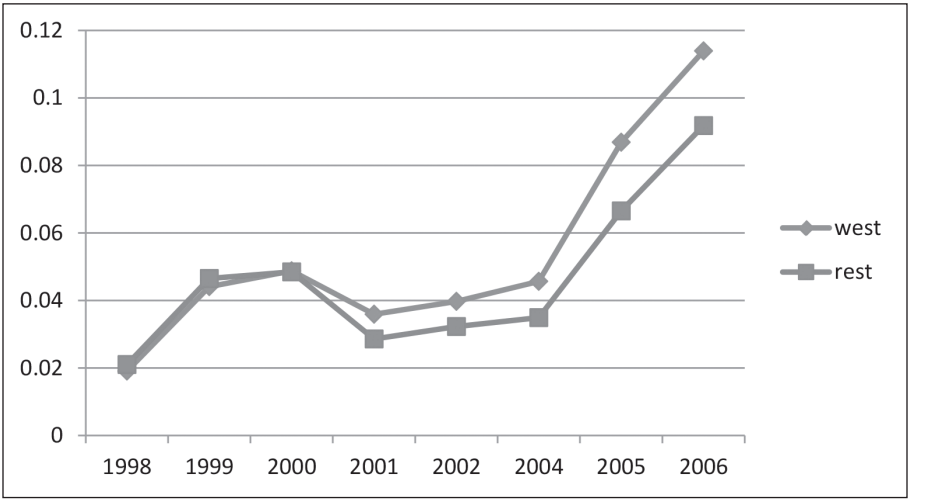
Figure 3. Differences in investment between Western and other regions



Note: The value is the mean of total investment in Western and other regions for each year. It refers to the total capital invested by each investor, including monetary, physical, intangible assets and other forms of investment. The data come from CMED.

Second, investment in R&D is higher in Western than in other regions, which raises productivity through technology updates. Since there is no data for R&D investment in our dataset, we use the fraction of intangible assets to total assets to capture R&D. In recent years, there has been a growing argument in literature that intangible assets present a major source of productivity growth, as seen in Corrado, Hulten, and Sichel (2009), Marrocu, Paci, and Usai (2011), and Crass and Peters (2013). They found that intangible assets contribute to a productivity-enhancing effect. In Figure 4, the fraction of intangible assets to total assets is larger in Western than in other regions after 2000.

Figure 4. The fractions of intangible assets in Western and other regions



Note: the intangible assets refer to the intangible assets that have been capitalized in the data set. Data for 2003 and 2007 are missing. The data comes from CMED.

Table 5: Gaps of ln(k/l) between Western and other regions

	(1) ln(k/l)	(2) ln(k/l)	(5) ln(k/l)
ln(age)	-0.0114***	-0.0125***	-0.0140***
	(0.0009)	(0.0009)	(0.0009)
D_trade	-0.0811***	-0.0789***	-0.0868***
	(0.0015)	(0.0015)	(0.0017)
D_state	0.1275***	0.1257***	0.0352***
	(0.0018)	(0.0018)	(0.0019)
D_foreign	0.1537***	0.1562***	0.1404***
	(0.0017)	(0.0017)	(0.0017)
D_west		0.0728***	0.0721***
		(0.0022)	(0.0022)
D_Sector	Yes	Yes	Yes
D_Year	No	No	Yes
N	1,722,501	1,722,501	1,722,501

Note: Standard errors in parentheses, *p< 0.05, **p< 0.01, ***p< 0.001.

Table 6: The mean firm size in Western and other regions 1998-2007

	Other	**Western**
1998	42,885.94	36,746.35
1999	55,128.29	47,704.10
2000	53,758.31	43,647.15
2001	56,626.28	47,995.00
2002	63,555.86	56,867.87
2003	75,018.55	69,146.54
2004	67,627.47	77,925.36
2005	78,893.24	83,380.06
2006	85,310.72	96,101.68
2007	95,803.84	111,819.60
Growth rate (%)	123.39	204.30

Note: The firm size is represented by gross output. The data comes from CMED.

The reduction of the corporate income tax promotes TFPR. Profitability increases because the rate of improving TFPQ is higher than firm expansion. Table 6 shows the development of firm size in Western and other regions during1998-2007. It is obvious that firm size increased significantly during this period for the whole country. However, firm size in Western increased more than in other regions. The growth rate of firm size in Western (204%) was nearly double that of the other regions (123%). However, the rate of firm size expansion is lower than TFPQ growth rate, perhaps because firms in Western faced many restrictions, such as transport infrastructure barriers, and human capital shortage.

6.1.2 The effect of VAT reform on productivity

In model (20), the methodology used to assess these effects compares the situation before and after preferential treatment in Western. In the case that only parts of industries in the treatment group benefited from the preferential policy, we expect to see differences in productivity across industries with and

without preferential treatment. The specification of the econometric model for estimating the effect of VAT reform in Northeast is:

$$Productivity_{sit} = \alpha_0 + \alpha_1 X_{sit} + \alpha_2 D_T + \alpha_3 D_{t>2004} + \alpha_4 (D_T \times D_{t>2004}) + \varepsilon_{sit} \quad (21)$$

where D_T is a dummy variable for industries that benefit from VAT reform in Northeast. It represents the treatment group. $D_{t>2004}$ indicates the year dummies for all of the post-policy differences.

The effect of VAT reform on productivity is shown in table 7. Columns (1) and (2) show the effect of VAT reform on TFPQ; columns (3) and (4) show the effect of corporate income tax reform on TFPR. The result presents the estimation of equation (21). Columns (2) and (4) are robustness checks with region dummies and year dummies. The results are robust.

The effect of taxation responds positively to TFPQ (0.26-0.29) and TFPR (0.19-0.23). The coefficients are statistically significant at the 1% level, suggesting that TFPQ and TFPR in the treatment group improve after preferential policy implementation.

The improved TFPQ and TFPR might have two causes. First, firms in Northeast invest more in fixed assets. Nie, Fang and Li (2009) argued that VAT reform has a positive effect on newly fixed assets in Northeast because reform reduces opportunity costs for firms using fixed assets; it is equal to reducing the price of capital (R). As a result, firms will increase investment on capital in the equilibrium. Table 8 shows that VAT reform produces positive effects ln (k/l), which means VAT reform encourages firms to invest more in fixed assets and that firms in the treatment group become more capital-intensive after VAT reform.

Table 7: The effect of VAT reform on TFPQ and TFPR in Northeast

	Log (TFPQ)		**Log (TFPR)**	
	(1)	**(2)**	**(3)**	**(4)**
$D_T \times D_{t>2004}$	0.294***	0.265***	0.230***	0.195***
	(0.0093)	(0.0086)	(0.0065)	(0.0061)
Ln(age)	-0.068***	-0.055***	-0.162***	-0.147***
	(0.0014)	(0.0014)	(0.0010)	(0.0010)
D_trade	0.1641***	0.136***	-0.043***	-0.128***
	(0.0023)	(0.0027)	(0.0017)	(0.0019)
D_state	-0.407***	-0.335***	-0.215***	-0.155***
	(0.0029)	(0.0030)	(0.0020)	(0.0021)
D_foreign	-0.022***	0.026***	-0.232***	-0.183***
	(0.0027)	(0.0027)	(0.0019)	(0.0019)
$D_{t>2004}$	0.3818***		0.1638***	
	(0.0022)		(0.0016)	
D_T	-0.251***		-0.196***	
	(0.0063)		(0.0044)	
D_Region	No	yes	No	Yes
D_Year	No	Yes	No	Yes
N	1,722,501	1,722,501	1,722,501	1,722,501

Note: Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Second, the productivity of old firms improved more because they benefited more from VAT reform than younger firms. Most old firms are SOEs firms that were founded decades ago. Reforming and restructuring SOEs is very important for revitalizing the Northeast because of their aging equipment. VAT reform is helpful to reduce the tax burden and encourage old SOEs to invest more in fixed assets. Table 9 shows that the coefficient of interaction term is positive and significant, which means productivity of old firms increases more from VAT reform than it does in younger firms.

VAT reform may have improved TFPR might perhaps because thousands of SOEs were bankrupt or closed. At the end of 2007, over 90% of SOEs were restricted under a shareholding system. During 2004-2005,

Chinese government closed 122 bankrupt SOEs in Liaoning, Jilin, and Heilongjiang provinces. These bankrupt SOEs were operating in old sectors, such as coal mining, and nonferrous metals (State Council Office for Revializing Northeast Old Industrial Base and Other Areas, 2005, 2006, 2008).

Table 8: The effect of VAT reform on ratio of labor to capital

	(1) **ln(k/l)**	**(2)** **ln(k/l)**
$D_{t>2004} \times D_T$	0.0208***	0.0558***
	(0.0062)	(0.0057)
Log (age)	-0.0056***	0.0843***
	(0.0009)	(0.0009)
D_trade	-0.2091***	-0.0871***
	(0.0015)	(0.0018)
D_state	0.0174***	0.0926***
	(0.0019)	(0.0020)
D_foreign	0.1097***	0.1647***
	(0.0018)	(0.0018)
D_T	0.0056	
	(0.0079)	
$D_{t>2004}$	-0.1779***	
	(0.0015)	
D_Northeast		0.2501***
		(0.0035)
D_region	Yes	No
D_sector	No	Yes
D_year	No	Yes
R^2	**0.7546**	**0.7473**

Note: Standard errors in parentheses, *p< 0.05, **p< 0.01, ***p< 0.001.

Table 9: The effect of VAT reform on productivity for old and younger firms

	(1) Log (TFPQ)	(2) Log (TFPR)
Treatment× D_age	0.0726***	0.0754***
	(0.0176)	(0.0124)
D_age	-0.1430***	-0.2456***
	(0.0026)	(0.0018)
Treatment	0.2511***	0.1819***
	(0.0091)	(0.0065)
D_trade	0.1349***	-0.1393***
	(0.0027)	(0.0019)
D_state	-0.3243***	-0.1724***
	(0.0030)	(0.0021)
D_foreign	0.0188***	-0.1949***
	(0.0027)	(0.0019)
N	1,722,501	1,722,501

Note: D_age is the dummy of old firms; firms are coded to 1 if firm age is greater than the mean of 14 years. Treatment is the equal to the DT×Dt>2004. Regressions control for year dummy, region dummy and sector dummy. The standard errors are in parentheses. *p< 0.05, **p< 0.01, ***p< 0.001.

Furthermore, columns (1) and (2) in Tables 4 and 7 show the effects of some other firms' characteristics on TFPQ, such as firm age, dummies of trading firms, SOEs, foreign firms and dummies of regions. A negative and statistically significant coefficient on firm age suggests that older firms have less productivity than younger firms, perhaps because younger firms have greater advantages with more modern technology and advanced institutions than older firms. Meanwhile, older firms face a heavy burden of social expenditures, overstaffing, and internal obstacles in management processes. A positive sign of coefficient of the export dummy shows that TFPQ is 1.3-13.2% higher in Western and 13.6-16.4% higher in Northeast for export firms compared with domestic firms. Consistent with this interpretation, Hsieh and Klenow (2009) argued that exporting plants have 46% higher TFPQ than domestic firms. The negative sign coefficients of state dummies means that

productivity of SOEs is 33-36% lower in Western and 33.5%-40.7% lower than that of non-SOEs. The results parallel those of Hsieh and Klenow (2009), who stated that the TFPQ of SOEs is 14% less than that of non-SOEs. The coefficients of foreign firms dummy are positive in Western, perhaps because foreign firms have better technology and institutional systems compared with domestic enterprises. The coefficients of foreign firms dummy do not show up as strongly robust in Northeast: unsurprising given that foreign firms are capital intensive, which correlates with investment.

The regional gaps of TFPQ are shown in rows 6-11 in tables 4 and 7. The Bohai Coastal region and Southeast are more developed regions with higher TFPQ; however, under-developed regions, such as Southwest and Northwest, show the lowest TFPQ. TFPQ in Central is the highest and consistent with the results of Nie and Jia (2011). The reason might be that Central took advantage of abundant human resources to develop high-technology industries such as software, new materials, and biological medicine. Central also has a good industrial foundation as China's earliest industrial region.

Columns (3) and (4) in tables 4 and 7 show the effect of other firms' characteristics on TFPR. The negative and significant coefficient of firm age shows that older firms have smaller revenue productivity compared with new entrants. The lower profitability can be explained by older firms having more advantages to select factors and easier credit access to expand production. The negative sign and significant coefficients of export dummy show that TFPRis12.0-13.1% lower in Western and 4.3-12.8% lower in Northeast for export firms compared with domestic firms. It is consistent with the results of Hsieh and Klenow (2009): 14% lower TFPR for exporting firms. The lower TFPR could reflect the expanding size of exporting firms. Estimated coefficients of state dummies are negative, which means TFPR is lower for SOEs than for non-SOEs. SOEs have easier access to credit, which is dominated by state-owned banks, and have fewer constraints on capital and labor, which allows them to expand production despite low profitability. The negative sign and significant coefficients of foreign-owned firms mean that TFPR is 18-23% lower for foreign-founded firms than for domestic firms. The result is consistent with Hsieh and Klenow (2009), who stated that TFPR of foreign firms is 12.9% lower than domestic firms.. The lower TFPR for foreign-founded firms results from the Chinese central government implementing a series of preferential policies on taxes, land, and investment for foreign-founded firms that led to the expansion of production.

Profitability in the Bohai coastal region and Central is higher than in other regions. However, the regions of Northwest and Southwest, which are under development, show less TFPR than in developed regions, perhaps because more investment is allocated to Western, which allows firms there to produce more than is optimal.

6.2 The effect of regional policy on resource misallocation at sector level

The study investigates the effect of corporate income tax and VAT reform on misallocation by region. The TFP efficiency gains are represented at the four-digit sector level.

6.2.1 The effect of corporate income tax on resource misallocation

In Western, we need to account for the likely dependence between observations from a given region and time period. The estimation is as follows:

$$Gain_{rst} = \alpha_0 + \alpha_1 Z_{rst} + \alpha_2 D_w + \alpha_3 D_{t>2001} + \alpha_w (D_w \times D_{t>2001}) + \upsilon_{rst} \quad (22)$$

where *r* indexes region, *t* indexes time, and *s* indexes sector. $Gain_{rst}$ is the TFP efficiency gains of a given region and time period for each sector. $D_{t>2001}$ is the dummy variable for each year after 2000. D_w is the dummy for 12 provinces in Western. Z_{rst} is the vector of control variables that are a fraction of SOEs, the fraction of the number of foreign-founded firms, the fraction of the number of trade firms, the average industrial firm age, and the Herfindahl-Hirschman Index (HHI) in each sector across six regions.

The results of regressions are shown in table 10. The coefficient of interaction term represents the effect of corporate income tax reform on resource misallocation. The coefficients of interaction terms are positive but not significant if equalizing the TFPR across firms within sector by region. The coefficient of interaction term is significant in robustness testing using the gain at provincial level, perhaps because the government-encouraged sectors differ across provinces. The analysis and estimation provide evidence that the reduction of the corporate income tax has a positive effect on distortion. In other words, a reduction in corporate income tax rates leads to an increasing misallocation of resource and efficiency loss.

The results provide evidence to support the ideas of Young (2000), who argued that economic reform might lead to more distortion because of

rent-seeking behavior. Faccio, Masulis, and McConnell (2006) stated that SOEs represent a strong form of political connection. They show that politically connected firms receive more because of preferential treatment. Table 10 shows that the resource misallocation is higher for SOEs than non-SOEs, perhaps because SOEs can easily benefit from the preferential policy but still exhibit low productivity.

Table 10: The effect of corporate income tax on resource misallocation

Variables	Gains by region		Gains by province	
	(1)	(2)	(3)	(4)
$D_w \times D_{t>2001}$	0.0160	0.0094	0.0605**	0.0539**
	(0.0407)	(0.0367)	(0.0294)	(0.0271)
Age	0.0001	-0.0000	-0.0002**	-0.0002*
	(0.0002)	(0.0002)	(0.0001)	(0.0001)
F_trade	-0.1880***	-0.4300***	-0.0987***	-0.2547***
	(0.0303)	(0.0529)	(0.0195)	(0.0301)
F_state	0.2372***	0.0679	0.4471***	0.3609***
	(0.0450)	(0.0504)	(0.0261)	(0.0281)
F_trade	0.0297	0.1526**	0.0777**	0.1963***
	(0.0636)	(0.0671)	(0.0336)	(0.0358)
HHI	-1.9838***	-2.1254***	-1.8247***	-1.9005***
	(0.0419)	(0.0431)	(0.0252)	(0.0257)
D_w	0.0152		-0.0754***	
	(0.0397)		(0.0260)	
Dt>2001	-0.1912***		-0.0634***	
	(0.0263)		(0.0170)	
D_region	No	Yes	No	Yes
D_year	No	Yes	No	Yes
N	24,576	24,576	75,695	75,695

Note: Columns (1) and (3) control for the dummy of Western and dummy of year after 2001. Columns (2) and (4) control for the year dummy and region dummy. Gains are divided by 100. Age is industry average age, F_trade is fraction of number of exporters, F_state is industry fraction of number of state-owned firms, F_foreign is industry fraction of number of foreign firms. Robust standard errors are in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$.

6.2.2 The effect of VAT reform on resource misallocation

In Northeast, for the case of selecting only several industries as a pilot to measure the effect of VAT reform on misallocation, the econometric model will be:

$$Gain_{rst} = \beta_0 + \beta_1 Z_{rst} + \beta_2 D_T + \beta_3 D_{t>2004} + \beta_{NE}(D_T \times D_{t>2004}) + \upsilon_{rst} \quad (23)$$

Where D_T is the dummy variable indicating the preferential sector. $D_{t>2004}$ indicates the preferential period. Gains are calculated by region and divided by 100.

The results of regression are shown in Table 11. The coefficient of interaction term is negative but not significant. It indicates that VAT reform has no effect on resource misallocation. The four-digit sector level TFP potential gains that are calculated by province have also been used for robustness testing. The results are the same, as shown in Appendix 2. The results are inconsistent with Jiang (2016), who argued that the 2004 VAT reform in Northeast reduced productivity dispersion and resource misallocation. However, Jiang (2016) used productivity dispersion as a proxy of misallocation. This research uses the ratio of actual TFP to the efficient level of TFP to represent resource misallocation.

Table 11: The effect of VAT reform on resource misallocation

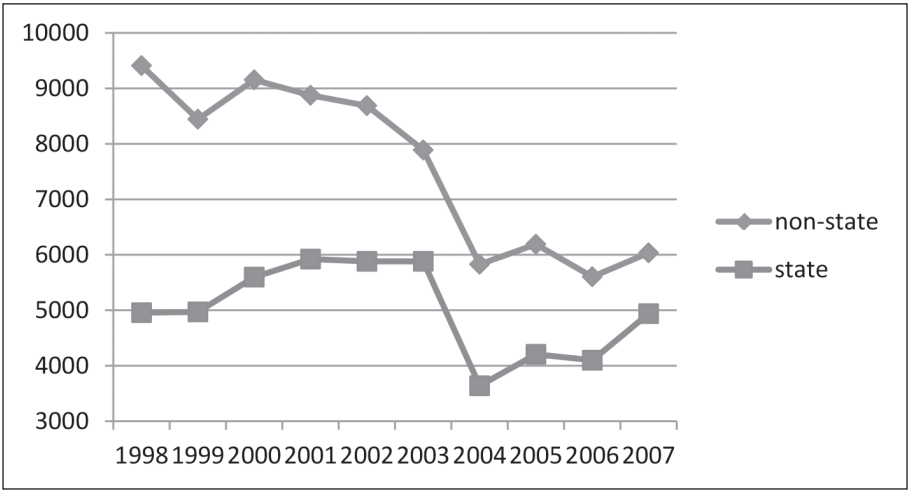
	(1) Gain	(2) Gain
$D_{t>2004} \times D_T$	-0.0359	-0.0422
	(0.0533)	(0.0532)
Age	0.0002	0.0001
	(0.0002)	(0.0002)
F_trade	-0.3119***	-0.5018***
	(0.0321)	(0.0526)
F_state	0.2512***	0.1313**
	(0.0440)	(0.0503)
F_foreign	0.0326	0.0738
	(0.0619)	(0.0660)
HHI	-2.0221***	-2.0194***
	(0.0412)	(0.0414)
$D_{t>2004}$	-0.1729***	
	(0.0246)	
D_T	0.3710***	0.3728***
	(0.0449)	(0.0448)
D_Year	No	Yes
N	24,576	24,576

Note: Column (1) controls for $D_{t>2004}$ and D_T , column (2) controls for $D_{t>2004}$ and year dummy. Iage is industry average age; F_trade is fraction of number of exporters; F_state is industry fraction of number of state-owned firms,; and F_foreign is industry fraction of number of foreign firms. Robust standard errors are in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.010$.

VAT reform has no effect on resource misallocation for three reasons. First, while VAT reform improves the efficiency of resource allocation by promoting productivity (Table 7), it intensifies misallocation because SOEs have more demand to purchase fixed assets than non-SOEs stimulated by VAT reform. Since most SOEs were founded decades ago and have long neglected

investment in fixed assets, they are more likely to purchase new equipment to replace their outdated production facilities. Figure 5, before 2004, shows fixed-asset increasing for SOEs but decreasing for non-SOEs. After 2004, fixed assets increased faster for SOEs than for non-SOEs. It indicates that investment in fixed assets for SOEs has been larger than for non-SOEs. Resource misallocation not only depends on the productivity level, but also on the demand for fixed assets. Second, we consider about the endogeneity problem. The regional policy could potential affect the long-run productivity. Therefore, TFPs, which are residuals, might be biased. This problem is inevitable and cannot be controlled. This might explain why the paper finds no effect from VAT reform on resource misallocation. Third, the research considers resource misallocation as an allocative efficiency gain that equalizes the TFPR across firms within sectors; thus more proxies need to be considered as a robustness check.

Figure 5. The median of fixed assets for SOEs and non-SOEs in Northeast



Note: We treat the change in fixed assets between two consecutive years as investment on fixed assets each year. This means a steeper slope indicates more investment. The data come from CMED.

In Tables 10 and 11, the results of control variables are shown in rows (2) to (6). The coefficient of age is not significant. The coefficients of fraction of exporters are negative since exporters face more competitive markets, which lead to less distortion. The coefficients of fraction of SOEs are positive because SOEs suffer more constraints from traditional management systems and government intervention. The coefficient of HHI is negative and significant, perhaps because monopolists have more resources for R&D to take advantage to innovate if profits from misallocation are smaller compared with technology updating. The monopolists improve their resource allocation by a spillover effect. The results suggest that it is necessary to promote merging and restructuring, especially for SOEs, and develop large corporate groups with international competitiveness.

This research provides heterosckeasticity and multicollinearity of robustness checks on baseline regressions. The research corrects for heteroskedasticity by robust standard errors. The results show that coefficients do not change using robust standard errors. This research tests for multicollinearity with a variance inflation factor (VIF) and correlation between variables. The results show no multicollinearity (VIF<5) problems in the model except for the dummy variables of regions. However, the collinear variables are only used as control variables, and they are not collinear with variables of interest, so we can safely ignore multicollinearity problems.

7. Conclusion

The research into the effect of resource misallocation on aggregate TFP has become an important topic. China has implemented several regional policies since 2000. These policy changes may affect resource allocation efficiency and TFP. Following Hsieh and Klenow's model, we measure the impact of resource allocation on the aggregate TFP by equalizing TFPR across firms within sectors across six regions in China. This paper then investigates the effects of the reduction of the corporate income tax rate and VAT reform on productivity and resource misallocation.

Our main finding is that government preferential policies promote TFPQ and TFPR to achieve development goals. For overall misallocation in China, the distortion worsened after 2006 to a point even worse than in 1998.

Resource misallocation increased significantly in the Northeast and Southwest. The results show that the reduction of the corporate income tax intensifies the resource misallocation. However, the value-added tax reform has no effect on resource misallocation.

Preferential policies are important to attract investment for underdeveloped regions. Reduction of corporate income tax and VAT reform promoted economic growth in Western and Northeast. However, preferential policies must be adjusted as some policy implications are based on the results of this research. First, policies and reforms should focus on updating technology. Innovation is important to promote competiveness, adjust industrial structures, and transform the pattern of economic growth. The central government should actively support new high-technology enterprises. Second, the heterogeneities of firms should be considered in implementing regional policies. Policies should respond to the different ages of firms, different ownership, different regions, different industries and the differences between exporting and domestic firms. Third, regional policies should respect the results of market choices and remove protections for SOEs. Since they have lower productivity, regional policy should focus on deepening the reform of SOEs, reducing subsidies to inefficient firms, and setting up competitive market environments for all enterprises. Fourth, the government should channel investment into foreign-owned firms and non-SOEs. Fifth, regional policy should expand the scope of industries that enjoy preferential policies. Preferential policy should focus on pillar industries and sustainable industries based on regional development and endowments.

However, the endogeneity problem is inevitable and might lead to results biased and not significant. This is an inherent weakness of this research. More research is needed to calculate the resource misallocation as a robustness check. Simulations of alternative policy proposals and their estimated effects could act as useful inputs to policymaking.

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Appendices

Appendix I Definitions of variables

Variables	Definitions
Output (Y_{si})	Value added
Capital (K_{si})	Book value of fixed assets of net depreciation.
Labor (L_{si})	Includes wage compensation and nonwage payment.
Labor share (α_s)	NBER productivity Database which is scaled up 3/2.
Wage	Wage payment for one year.
Nonwage payment	Assume that nonwage benefits are a constant fraction of a plant's wage compensation, where the adjust factor is calculated such that the sum of imputed benefits and wages across all plants equals 50% of aggregate value added.
Capital labor share (k/l)	The ratio of capital to labor compensation. k/l= K_{si} / L_{si}
Firm age	Years of plant operated. Firm age=Reported year- founded year+1
Dummy of exporting firms	We define the trade firms as the one which the export value is not equal to 0. Trading firms=1 Non trading=0
Dummy of foreign firms	Foreign investment firms=1 Domestic investment firms=0
Dummy of State-owned enterprises	State owned enterprises=1 Non-state owned enterprises=0
Industry code	Chinese industrial code (GB/T 4754-2002) refers to 481 sectors at 4-digit level and 28 sectors at 2-digit level.
Industry average plant age	Average age across firms in each industry.
Industry fraction of state owned enterprises	Fraction of total number of state own enterprises in each industry
Industry fraction of exporting firms	Fraction of total number of trading plants in each industry
Industry faction of foreign firms	Fraction of total number of foreign investment firms in each industry
Herfindahl-Hirschman Index (HHI)	$\sum_{i=1}^{s}\left(\text{sales\_value}_{si}/\sum_{i=1}^{s}\text{sales\_value}_{si}\right)^2$

Appendix II The effect of VAT reform on resource misallocation by province

Variables	**Gain (1)**	**Gain (2)**
$D_{t>2004} \times D_T$	-0.0668	-0.0718
	(0.0458)	(0.0458)
Age	-0.0002	-0.0002
	(0.0001)	(0.0001)
F_trade	-0.1491***	-0.2879***
	(0.0201)	(0.0298)
F_state	0.3889***	0.3976***
	(0.0255)	(0.0280)
F_foreign	0.0861**	0.1504***
	(0.0325)	(0.0346)
hhi	-1.8557***	-1.8619***
	(0.0247)	(0.0247)
D_2004	-0.1096***	
	(0.0157)	
D_T	0.3834***	0.3812***
	(0.0308)	(0.0308)
D_year	No	Yes
N	75,695	75,695