Factor market distortion in China's manufacturing industry

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Abstract

Hsieh and Klenow (2009) link overall firm-level dispersions in marginal products to potential improvement of aggregate TFP in a monopolistic competition model. In this paper I extend their strategy on two counts. First, I decompose total distortions into systematic components and idiosyncratic residuals. Systematic components identify the sources of distortion in the structure of factor markets, i.e. labour distortion across regions, capital distortions across segments and across sectors. Second, I measure distortion components as the impact on aggregate output. Aggregate TFP used by Hsieh and Klenow (2009) fails to capture distortions across sectors. Measuring distortions in China's manufacturing sectors from 1998 to 2007 elicits two important findings. The evolution of the measures shows clear reduction of labour distortion across regions and capital distortion across segments, but limited unwinding of capital misallocation across sectors. In addition, the large magnitude of the remaining distortions in 2007 suggests policies to further reduce systematic distortions, especially for capital distortion across sectors.

JEL codes: O4, R2, L5

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1 Introduction

As input growth slows down[1] and the technology gap with advanced countries narrows[2], more efficient factor allocation becomes critical to develop the growth potential of China's manufacturing sectors. Product and factor market distortions squeezed out in the process of economic transformation have promoted the aggregate productivity growth to some extent, e.g. migration of surplus labour from low-productive agriculture to industry, and joint-stock reform of state-owned banks. However, there remain some structural barriers that hinder the further population movement across regions, such as the Hukou system (Chan and Zhang, 1999). Since governments at various levels actively interfere in the functioning of capital market, state-dominated banks often employ credit policies biased towards urban state-owned firms or selective manufacturing sectors (Boyreau-Debray and Wei, 2004). In contrary, product markets have become more integrated since the early 1990s when government took measures to remove the interregional trade barriers (Holz, 2009). Remaining output distortions might stem from local protectionism (Young, 2000), size restriction (Guner et al., 2008) or geographical constraints on transportation costs.

All these market impediments systematically give rise to dispersions in labour and capital productivity across firms. In this paper, I decompose firm-specific distortions into a systematic part that is associated with misallocation in the structure of economy, and a residual idiosyncratic part. Measuring the systematic distortions helps identify the underlying sources and magnitude of factor market distortions and suggest policy directions to improve economic efficiency. Hsieh and Klenow (2009) develop a theoretical model to link overall firm-level dispersions in marginal products of labour and capital to aggregate TFP. Using the same framework, I measure each component of distortions as its impact on aggregate output.

Each systematic distortion subdivides the factor market into clearly identifiable segments. Factor immobility across segments incites disparity in factor returns. Suppressing return differentials across segments would leave the remaining distortions in idiosyncratic residuals within segments. Idiosyncratic residuals within segment are likely to involve other systematic distortions and a hypothetical random error. By normalizing idiosyncratic residuals, I divide total labour distortions of each manufacturing sector into the systematic

[1] National Population and Birth Control Committee predicts that the size of Chinese population peaks in 2033 and is quickly aging afterwards. On the other hand, manufacturing investment growth declines 9.8% in 2012. Higher labour costs or particular political pressures are shifting assembly lines of some international manufacturing out of China, e.g. Nike and Apple.

[2] China's FDI outflows, part of which is used to procure western businesses for technology, brands and know-how, increase rapidly from US$0.9 billion in 1991 to US$77.2 billion in 2012. Mergers and acquisitions account for US$37.8 billion, or 49% of the total.

component across regions and the idiosyncratic component within regions. Capital distortions of each sector are separated into differentials between and within firm-segments, where firms in each segment are exposed to similar financing cost of capital, e.g. big state-owned enterprises (SOEs) in urban areas vs. small private businesses in rural areas.

Hsieh and Klenow (2009) assume different technology for each industry and aggregate industrial TFP gains of total distortion reduction across manufacturing sectors using Cobb-Douglas. Since aggregate TFP of each industry is linked to marginal product dispersions within the sector, aggregate manufacturing TFP used in Hsieh and Klenow (2009) neglects measuring distortions across sectors and understates the potential economic efficiency in full liberalization. I measure the distortion across sectors as the impact on aggregate output, taking into account factor allocations across sectors. Government-directed manufacturing investment makes capital distortion across sectors an important source of systematic distortions in China.

In a similar framework, Brandt et al. (2013) construct province-level data and measure the distortions across provinces and between state and nonstate sector with aggregate TFP, assuming all sectors use technologies that have the same factor elasticities. My work differs in three aspects. First, I use firm-level information. Capital segments categorize firms in different level of ownership, urbanization, and size, rather than the simple state and nonstate classification. Second, I additionally measure the systematic distortions across sectors. Each industry is assumed to use different technology on production. Third, I also measure the idiosyncratic distortions that are excluded in macro-data. Idiosyncratic distortions incorporate policy distortions, random shocks and the remaining sources of misallocation.

The evolution of the distortion measures reflects the improvement of allocative efficiency. Using firm census data in China's manufacturing sectors for period 1998-2007, I find a clear reduction of labour distortion across regions and capital distortion across segments. Within manufacturing sectors, labour distortion across regions and capital distortion across segments account for less than one-fifth of total labour and capital distortion in 2007, but contribute to more than two-thirds of the total distortion reductions over the period. In contrast, unwinding of the capital misallocation across sectors is limited.

The large magnitude of the existing systematic distortions indicates that improvement of labour mobility across regions and capital mobility across segments and across sectors is still important to promote overall economic efficiency. In 2007, about one-fifth of total growth potential in efficient allocation is able to be achieved by eliminating these systematic distortions. I investigate the dispersions in factor products across those three dimensions and propose realistic policies, e.g. inland shift of labour-intensive manufacturing, development of small credit markets, and a reduced role of government in financing manufacturing sectors.

This paper is related to the literature that measures the effects of misallocation on aggregate productivity. Early studies on misallocation in China examine the dispersions in factor returns and provide insights of specific systematic distortions in factor markets. Gong and Xie (2006) and Boyreau-Debray and Wei (2004) reveal low capital mobility across the provinces in the 1990s. Zhang and Tan (2007) suggest that labour markets are becoming more integrated, but capital markets have become more fragmented between urban and rural and between farm and nonfarm sectors. Dollar and Wei (2007) highlight the capital misallocation between state and nonstate sectors. In the studies that examine the impact of other sources of misallocation on aggregate productivity, Restuccia et al. (2008) and Vollrath (2009) analyze cross-country differences in aggregate TFP due to the misallocation between agriculture and industry. Restuccia and Rogerson (2008) and Bartelsman et al. (2009) assess the impact of idiosyncratic policy distortions in accounting for cross-country differentials.

The rest of the paper is organized as follows. The next section illustrates the methodologies that decompose and measure distortions. In section 3, I will describe the micro-level data set and approaches to calibrate the model parameters. Section 4 decomposes total distortions into idiosyncratic and systematic components. Section 5 simulates the counterfactual factor reallocations and offers policy implications. I conclude in section 6.

2 Methodology

2.1 Model

Hsieh and Klenow (2009) derive industrial aggregate TFP as a function of factor distortions in a monopolistic competition model. I break down the total distortion into systematic components and idiosyncratic residuals. All distortion components are incorporated into aggregate output.

Following Hsieh and Klenow (2009), I assume the total output of economy Y aggregates each industry i's output Y_i, $(i = 1, ..., N)$, using a Cobb-Douglas technology:

$$Y = \prod_{i=1}^{N} Y_i^{\theta_i}, \text{ where } \sum_{i=1}^{N} \theta_i = 1$$

Profit maximization implies $P_i Y_i = \theta_i P Y$ where $P \equiv \prod_{i=1}^{N} (P_i/\theta_i)^{\theta_i}$.

The industry output Y_i itself is a CES aggregate of M_i differentiated products

$$Y_i = \left(\sum_{j=1}^{M_i} Y_{ij}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}$$

Profit maximization yields $\frac{Y_{ij}}{Y_i} = \left(\frac{P_{ij}}{P_i}\right)^{-\sigma}$ where $P_i \equiv \left(\sum_{j=1}^{M_i} P_{ij}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$. The elasticity of demand for Y_{ij} approximately equals $-\sigma$ given very small share of one single firm in the total industry.[3]

Each industry uses different technology to produce the differentiated products

$$Y_{ij} = A_{ij} L_{ij}^{\alpha_i} K_{ij}^{1-\alpha_i}$$

Each firm j in industry i maximizes the profit

$$\pi_{ij} = P_{ij}Y_{ij} - \frac{WL_{ij}}{(1-\tau_i^l)(1-\tau_{ir}^l)(1-\tau_{ij}^l)} - \frac{RK_{ij}}{(1-\tau_i^k)(1-\tau_{is}^k)(1-\tau_{ij}^k)}$$

which yields $P_{ij} = \frac{\sigma}{\sigma-1} \left(\frac{W}{\alpha_i(1-\tau_i^l)(1-\tau_{ir}^l)(1-\tau_{ij}^l)} \right)^{\alpha_i} \left(\frac{R}{(1-\alpha_i)(1-\tau_i^k)(1-\tau_{is}^k)(1-\tau_{ij}^k)} \right)^{1-\alpha_i} \frac{1}{A_{ij}}$. Hsieh and Klenow (2009) set constant W and R and infer the total distortion across firms from the first order conditions of inputs. Here I allow a location specific wage $W_r^i = \frac{W}{(1-\tau_i^l)(1-\tau_{ir}^l)}$ for region r in industry i and segment specific cost of capital $R_s^i = \frac{R}{(1-\tau_i^k)(1-\tau_{is}^k)}$ for segment s in industry i. τ_i^l and τ_i^k capture the distortions that marginal products of factor differ across sectors. For instance, τ_i^k would be low for the industries that have easy access to government aids, and high for industries with long payback period or long-term cash flow. τ_{ir}^l measures regional disparity of labour productivity. It would be low for inland provinces and high for the coastal regions in China. τ_{is}^k reflects the dispersion of capital returns in different firm segments. It would be low for large state-owned firms, but high for small private businesses. τ_{ij}^l and τ_{ij}^k thus are the remaining idiosyncratic labour or capital (relative to output) distortions.[4] Those distortions bring about the dispersions in marginal revenue product of labour and capital, i.e. $MRPL$ and $MRPK$. First order conditions of labour and capital give

$$MRPL_{ij} = \alpha_i \frac{\sigma-1}{\sigma} \frac{P_{ij}Y_{ij}}{L_{ij}} = \frac{W_r^i}{1-\tau_{ij}^l} \quad (1)$$

$$MRPK_{ij} = (1-\alpha_i) \frac{\sigma-1}{\sigma} \frac{P_{ij}Y_{ij}}{K_{ij}} = \frac{R_s^i}{1-\tau_{ij}^k} \quad (2)$$

[3]The elasticity of demand for Y_{ij} is $-\eta_{ij} = -\sigma + S_i(\sigma - \eta_i) \approx -\sigma$, where $S_i = \frac{P_{ij}Y_{ij}}{P_iY_i}$ and η_i is the elasticity of industry output Y_i.

[4]In the equivalent full settings, I separately define an output distortion together with pure labour and capital distortions. $\max_{L_{ij},K_{ij}} \left\{ (1-\tau_{ij}^y)P_{ij}Y_{ij} - \frac{W_r^i}{1-\tau_{ij}^{l*}} L_{ij} - \frac{R_s^i}{1-\tau_{ij}^{k*}} K_{ij} \right\}$ Therefore, $\frac{1}{1-\tau_{ij}^l} = \frac{1}{(1-\tau_{ij}^y)(1-\tau_{ij}^{l*})}$ and $\frac{1}{1-\tau_{ij}^k} = \frac{1}{(1-\tau_{ij}^y)(1-\tau_{ij}^{k*})}$.

Specific distributional assumptions of idiosyncratic distortions are required to separate the systematic and idiosyncratic components, i.e. W_r^i and τ_{ij}^l in (1), and R_s^i and τ_{ij}^k in (2). Suppose average idiosyncratic distortions weighted by revenue are normalized to zero for each sector-region and each sector-segment, i.e. $\sum\limits_{j\in r, j\in i} \tau_{ij}^l \frac{P_{ij}Y_{ij}}{\sum\limits_{j\in r,j\in i} P_{ij}Y_{ij}} = 0$ and $\sum\limits_{j\in s, j\in i} \tau_{ij}^k \frac{P_{ij}Y_{ij}}{\sum\limits_{j\in s,j\in i} P_{ij}Y_{ij}} = 0$.[5] $L_r^i = \sum_{j\in r} L_{ij}$ and $K_s^i = \sum_{j\in s} K_{ij}$ aggregate demand of labour in sector-regions and capital in sector-segments. W_r^i and R_s^i are solved as revenue-weighted average $MRPL$ in region r and $MRPK$ in segment s respectively.

$$
\begin{aligned}
W_r^i &= \frac{\sigma-1}{\sigma}\frac{\alpha_i \sum\limits_{j\in r} P_{ij}Y_{ij}}{L_r^i}\left(\sum_{j\in r}(1-\tau_{ij}^l)\frac{P_{ij}Y_{ij}}{\sum\limits_{j\in r} P_{ij}Y_{ij}}\right) = \frac{\sigma-1}{\sigma}\frac{\alpha_i \sum\limits_{j\in r} P_{ij}Y_{ij}}{L_r^i} \\
&= \frac{1}{\sum\limits_{j\in r}\frac{1}{MRPL_{ij}}\frac{P_{ij}Y_{ij}}{\sum\limits_{j\in r} P_{ij}Y_{ij}}} \triangleq \overline{MRPL}_{ir}
\end{aligned}
$$

Similarly,

$$
R_s^i = \frac{\sigma-1}{\sigma}\frac{\alpha_i \sum\limits_{j\in s} P_{ij}Y_{ij}}{K_r^i} = \frac{1}{\sum\limits_{j\in s}\frac{1}{MRPK_{ij}}\frac{P_{ij}Y_{ij}}{\sum\limits_{j\in s} P_{ij}Y_{ij}}} \triangleq \overline{MRPK}_{is}
$$

Idiosyncratic distortions τ_{ij}^l, τ_{ij}^k can then be calculated from (1) and (2),

$$
\begin{aligned}
\frac{1}{1-\tau_{ij}^l} &= \alpha_i \frac{\sigma-1}{\sigma}\frac{P_{ij}Y_{ij}}{W_r^i L_{ij}} \\
\frac{1}{1-\tau_{ij}^k} &= (1-\alpha_i)\frac{\sigma-1}{\sigma}\frac{P_{ij}Y_{ij}}{R_s^i K_{ij}}
\end{aligned}
$$

Analogously normalizing systematic distortions within each industry i, i.e. $\sum\limits_r \tau_{ir}^l \frac{\sum_{j\in r} P_{ij}Y_{ij}}{P_iY_i} = 0$ for labour and $\sum\limits_s \tau_{is}^k \frac{\sum_{j\in s} P_{ij}Y_{ij}}{P_iY_i} = 0$ for capital, we have industrial weighted average marginal products that are determined only by cross-sector distortions.

$$
\begin{aligned}
\overline{MRPL}_i &\triangleq \frac{1}{\sum\limits_{j=1}^{M_i}\frac{1}{MRPL_{ij}}\frac{P_{ij}Y_{ij}}{P_iY_i}} \\
&= \frac{W}{(1-\tau_i^l)\sum\limits_r\left[(1-\tau_{ir}^l)\frac{\sum_{j\in r} P_{ij}Y_{ij}}{P_iY_i}\sum\limits_{j\in r}(1-\tau_{ij}^l)\frac{P_{ij}Y_{ij}}{\sum\limits_{j\in r} P_{ij}Y_{ij}}\right]} = \frac{W}{1-\tau_i^l} \\
\overline{MRPK}_i &\triangleq \frac{1}{\sum\limits_{j=1}^{M_i}\frac{1}{MRPK_{ij}}\frac{P_{ij}Y_{ij}}{P_iY_i}} = \frac{R}{1-\tau_i^k}
\end{aligned}
$$

[5] Namely, $E_{ir}\left[\tau_{ij}^l P_{ij}Y_{ij}\right] = 0$ and $E_{is}\left[\tau_{ij}^k P_{ij}Y_{ij}\right] = 0$.

Cross-region labour distortion τ^l_{ir} and cross-segment capital distortion τ^k_{is} can then be solved as

$$\begin{aligned}\frac{1}{1-\tau^l_{ir}} &= \frac{\overline{MRPL}_{ir}}{\overline{MRPL}_i}\\ \frac{1}{1-\tau^k_{is}} &= \frac{\overline{MRPK}_{is}}{\overline{MRPK}_i}\end{aligned}$$

Now define revenue productivity for the firms and industry

$$\begin{aligned}TFPR_{ij} &\triangleq P_{ij}A_{ij} = \frac{\sigma}{\sigma-1}(\frac{MRPL_{ij}}{\alpha_i})^{\alpha_i}(\frac{MRPK_{ij}}{1-\alpha_i})^{1-\alpha_i}\\ TFPR_i &\triangleq P_iA_i = \frac{\sigma}{\sigma-1}(\frac{\overline{MRPL}_i}{\alpha_i})^{\alpha_i}(\frac{\overline{MRPK}_i}{1-\alpha_i})^{1-\alpha_i}\end{aligned}$$

We can calculate the aggregate TFP for the industry[6]:

$$A_i = \frac{Y_i}{L_i^{\alpha_i}K_i^{1-\alpha_i}} = \left[\sum_{j=1}^{M_i}\left(A_{ij}\frac{TFPR_i}{TFPR_{ij}}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}$$

This equation translates the dispersions of revenue productivity into the aggregate TFP. Revenue productivities are written as a function of distortion parameters. Reducing dispersion in marginal product for any improvement of distortions within sectors will lead to a higher aggregate TFP. In this framework, firm productivity is taken exogenously and does not vary with distortions. In the model specification we know firm productivity $A_{ij} = \kappa_i\frac{(P_{ij}Y_{ij})^{\frac{\sigma}{\sigma-1}}}{L_{ij}^{\alpha_i}K_{ij}^{1-\alpha_i}}$ where $\kappa_i = (P_iY_i)^{-\frac{1}{\sigma-1}}/P_i$ is industry constant. Although it is not directly observed, I can simply set $\kappa_i = 1$ as reallocation gains depend only on the ratios of aggregate TFP and output change. We can also infer the price vs. quantity using the assumed elasticity of demand. High real output is demanded when price is low. Hsieh and Klenow (2009) simply proxy the real output Y_{ij} by $(P_{ij}Y_{ij})^{\frac{\sigma}{\sigma-1}}$, which equalizes the demand factors across all the sectors.

2.2 Distortion Measures

Given any set of distortions W^i_r, R^i_s, τ^l_{ij}, and τ^k_{ij}, we obtain the unique competitive allocations within and between the industries.[7]

$$\begin{aligned}L_i &= \sum_{j=1}^{M_i} L_{ij} = L\frac{\alpha_i\theta_i/\overline{MRPL}_i}{\sum_{i'=1}^N \alpha_{i'}\theta_{i'}/\overline{MRPL}_{i'}}\\ K_i &= \sum_{j=1}^{M_i} K_{ij} = K\frac{(1-\alpha_i)\theta_i/\overline{MRPK}_i}{\sum_{i'=1}^N (1-\alpha_{i'})\theta_{i'}/\overline{MRPK}_{i'}}\end{aligned}$$

[6] See formula appendix for the derivation.

[7] I do not show the formula of equilibrium allocation within the industries L_{ij}/L_i and K_{ij}/K_i because it is not used in the following calculations. Available upon request.

where L and K are aggregate supply of labour and capital.

For any improvement of distortions, I can calculate the aggregate output $Y^{'}$ and compare it with the actual level. All the industries' outputs are aggregated with the unit elasticity of substitution.

$$\frac{Y^{'}}{Y} = \prod_{i=1}^{N} \left(\frac{A_i^{'} L_i^{'\alpha_i} K_i^{'1-\alpha_i}}{A_i L_i^{\alpha_i} K_i^{1-\alpha_i}} \right)^{\theta_i}$$

Holding the cross-sector distortions τ_i, eliminating overall within-sector distortions only equalizes the marginal products of individual firms at the industrial average and does not change factor allocations cross sectors. The increase of aggregate outputs then reproduces the aggregate TFP gain of full liberalization in Hsieh and Klenow (2009):

$$A^*/A = \prod_{i=1}^{N} \left[\sum_{j=1}^{M_i} \left(\frac{A_i^*}{A_{ij}} \frac{TFPR_i}{TFPR_{ij}} \right)^{\sigma-1} \right]^{\frac{\theta_i}{\sigma-1}}$$

where $A_i^* = \sum_{j=1}^{M_i} \left(A_{ij}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}$ is the aggregate TFP for industry i when marginal products are equalized across firms. Aggregating the ratios of A_i^*/A_i across sectors in Hsieh and Klenow (2009) thereby failed to capture the improvement of cross-sector allocative efficiency[8], but is appropriate to measure total within-sector distortions. Eliminating part of the within-sector distortions could cause slight reallocation across sectors as industrial average marginal revenue products vary in a function of distortion parameters.[9]

In my extension, I can calculate the counterfactual aggregate output of eliminating any particular distortion and measure its contribution to the actual aggregate output. Simultaneously eliminating τ_{ir}^l and τ_{ij}^l removes all the labour distortion in the industry while eliminating τ_{ir}^l itself only drops the regional disparity in marginal product of labour. Accordingly, eliminating τ_{is}^k excludes the segmental disparity in capital returns. Capital distortions within sectors are rooted out when τ_{ij}^k is additionally removed. The dispersion of marginal products or TFPR is lessened by either entirely or partially removing these within-sector distortions, which increases the aggregate TFP of all the industries. The most efficient TFP is achieved when we simultaneously wipe out all the within-sector distortions τ_{ir}^l, τ_{ij}^l, τ_{is}^k and τ_{ij}^k. This is equivalent to the full liberalization case in Hsieh and Klenow (2009). Additionally eliminating distortions across sectors τ_i^l and τ_i^k results in efficient allocation across sectors and reflects the largest economic growth potential for allocative efficiency improvement.

[8]Hsieh and Klenow (2009) claim that cross-sector allocation are unchanged in full liberalization because of the unit elastic demand. However, this implicitly assumes fixed aggregate output revenue.

[9]See the formula appendix. Average of the remaining within-sector distortions weighted by the changed revenue shares does not necessarily equal zero.

Borrowing the definition of Brandt et al. (2013), I measure distortions in log-points. The overall distortion is measured as

$$D = \ln(Y^*/Y)$$

where Y^* is the aggregate output of full liberalization. Y is the actual aggregate output. The advantage of this log-point measure is that it can be divided into additive distortion components, e.g. $\ln(Y^*/Y) = \ln(Y^*/Y_{nwi}) + \ln(Y_{nwi}/Y)$ where Y_{nwi} is the aggregate output when all the within-sector distortions are eliminated. The first term measures the cost of distortions across sectors from the efficient allocation. The second one is the contribution of distortions within sectors. The disadvantage is that log-points might understate the potential improvement of aggregate output for large magnitude.

I can measure regional labour distortion and segmental capital distortion within sectors as the contribution of eliminating between- distortions to the actual aggregate output:

$$\begin{aligned} d_{br} &= \ln(Y_{nbr}/Y) \\ d_{bs} &= \ln(Y_{nbs}/Y) \end{aligned}$$

Corresponding idiosyncratic distortion measures are

$$\begin{aligned} d_{wr} &= \ln(Y_{nwr}/Y) \\ d_{ws} &= \ln(Y_{nws}/Y) \end{aligned}$$

Let Y_{nbr} and Y_{nbs} be the aggregate output when only between-region labour distortion or between-segment capital distortion is eliminated. Y_{nwr} and Y_{nws} are the aggregate output when there is no within-region labour distortion or within-segment capital distortion.

The alternative measures are to quantify the aggregate output losses (in log-points) that existence of the distortions will beget from the factor market liberalization.

$$\begin{aligned} D_{br} &= \ln(Y^l_{nwi}/Y_{nwr}) \text{ and } D_{wr} = \ln(Y^l_{nwi}/Y_{nbr}) \\ D_{bs} &= \ln(Y^k_{nwi}/Y_{nws}) \text{ and } D_{ws} = \ln(Y^k_{nwi}/Y_{nbs}) \end{aligned}$$

where Y^l_{nwi} and Y^k_{nwi} are the aggregate output eliminating all within-sector labour and capital distortions respectively. Between- measures indicate the costs of the aggregate distortions in factor market when factor returns within region or segment are equalized. Within- measures are the costs of the remaining distortions when regional or segmental disparity is removed.

Given the exogenous firm-level productivity, eliminating distortions across sectors does not alter the aggregate TFP for each industry but could improve the allocation across sectors and enhance aggregate output. I measure the effects of reallocation across sectors as follows.

$$
\begin{aligned}
d^l_{bi} &= \ln(Y^l_{nbi}/Y) \\
d^l_{bi} &= \ln(Y^k_{nbi}/Y)
\end{aligned}
$$

Y^l_{nbi} and Y^k_{nbi} are the total output when industrial average marginal products of labour or capital are equalized.

Cost measures of the cross-sector distortions are

$$
\begin{aligned}
D^l_{bi} &= \ln(Y^l/Y^l_{nwi}) \\
D^k_{bi} &= \ln(Y^k/Y^k_{nwi})
\end{aligned}
$$

Y^l and Y^k are the aggregate output for eliminating all labour and capital distortions respectively. Cost and contribution measures are exactly the same for the distortions across sectors since they both improve from the actual sectoral allocation to efficient allocation across sectors, i.e. $L_i = L\frac{\alpha_i\theta_i}{\sum_{i'=1}^N \alpha_{i'}\theta_{i'}}$ or $K_i = K\frac{(1-\alpha_i)\theta_i}{\sum_{i'=1}^N (1-\alpha_{i'})\theta_{i'}}$, with unchanged aggregate TFP for each industry.

Measuring distortions using aggregate output especially for allocative efficiency across sectors is somehow sensitive to the model specification. It relies on the Cobb-Douglas aggregation of final output. Expenditure share on each industry is assumed to be fixed. This appears to fit China's manufacturing data well. Correlation of 4-digit sector shares in total value-added between 1998 and 2007 is 0.83.[10] Most of the manufacturing sectors share the booming in the past ten years and it may be also foreseen for the next decade. Relaxing the Cobb-Douglas aggregator alters the allocation equilibrium across industries.[11][12] In a robustness check, I use a general CES function as a closer depiction of reality to test distortions across sectors.

3 Data

I use the firm-level census data from 1998 to 2007 for all manufacturing sectors. It consists of all the state-owned firms and nonstate firms with more than 5 million RMB revenue. The

[10] Correlation of sector shares in total value-added between 1998 and 2007 is 0.92 at 2-digit level.

[11] For a CES aggregator of final output, $Y = \left(\sum_{i=1}^N \theta_i Y_i^{\frac{\phi-1}{\phi}}\right)^{\frac{\phi}{\phi-1}}$, the allocation equilibrium is $L_i = L\frac{\alpha_i\theta_i^\phi P_i^{1-\phi}/\overline{MRPL}_i}{\sum_{i'=1}^N \alpha_{i'}\theta_{i'}^\phi P_{i'}^{1-\phi}/\overline{MRPL}_{i'}}$ and $K_i = K\frac{(1-\alpha_i)\theta_i^\phi P_i^{1-\phi}/\overline{MRPK}_i}{\sum_{i'=1}^N (1-\alpha_{i'})\theta_{i'}^\phi P_{i'}^{1-\phi}/\overline{MRPK}_{i'}}$.

[12] For a CES aggregator, I can still approximately aggregate gains of within-sector allocative efficiency, $\sum_i \theta_i \ln(A_i^*/A_i)$. However, it no longer matches the output change of eliminating total within-sector distortions.

number of firms in census increases from slightly less than 150,000 in 1998 to over 310,000 in 2007. The variables include firm's industry code, location, ownership, employment, wage payment, value-added and capital stock. Hsieh and Klenow (2009) simply use the fixed capital stock reported by firm at the original purchase prices. I follow the method of Brandt et al. (2012) converting the book value of capital stock into the real values that are comparable across time and across firms. Real capital stock is calculated using the perpetual inventory method with a 9% depreciation rate and Brandt-Rawski investment deflator.[13]

$\Rightarrow$ Insert Table 1 approximately here $\Leftarrow$

Table 1 provides the descriptive statistics on the underlying data set. Value-added and output are translated into 1998 price level with a discount factor reflecting the factory price indices of industrial goods. Input growth, i.e. 48% for employment and 111% for fixed capital, is insufficient to explain the fivefold increase of value-added or output from 1998 to 2007. Using China's industrial data for the same period, Brandt et al. (2012) and Gan and Zheng (2009) both report an annual TFP growth of 8% on average. Most of them seem to be attributed to the improvement of technical efficiency as Hsieh and Klenow (2009) report only 2% per year TFP growth associated with better allocations of resources. This suggests the considerable importance to investigate the systematic part of total factor market distortions.

To estimate the effects of misallocation, I first need to pin down the key parameters of the model, i.e. industry output share θ_i, industry labour share α_i, and the elasticity of substitution between firms σ. $\theta_i = \frac{P_i Y_i}{PY}$ is the industry share in total output revenue. But since the model allows little room for the measurement error, I trim the top and bottom 1% tails of labour and capital distortions and (revenue) productivity respectively within each industry before calculating the shares. Hsieh and Klenow (2009) and Brandt et al. (2013) set α_i directly as the industrial labour share in the United States[14], because the labour share in China deviates from the labour production elasticity due to the distortions.[15] Likewise, I map all NAICS industries into Chinese industry coding (CIC) and scale up labour shares in US ASM data by 3/2 to take into account all the other fringe benefits and Social Security contributions. Without the price information, I could not estimate the elasticity of substitution per industry. The easy way is to set a conservative σ for all

[13]Brandt et al. (2012) provide an online appendix to describe all the methodology to construct the panel data.

[14]This implicitly assumes that labour shares in fixed costs covered by markup is the same as the labour shares in variable costs.

[15]Qian and Zhu (2013) find low correlation between labour income shares in China and in US using alternative measures of labour share and explain the differentials by capital market distortions.

the industries, i.e. $\sigma = 3$ in Hsieh and Klenow (2009). A robustness check can be made for a more aggressive σ.

I observe both employment and wage bills. Labour share as the wage bill over value-added has a median only about 30% in the data set. So following Hsieh and Klenow (2009) I assume a constant proportion of benefits added into wage such that total labour benefits of all the firms in the sector equal 50% of aggregate value-added. One important issue is the labour heterogeneity across firms. Employment in different firms could be quite different. Wage per worker may vary within the region due to more the differences of work hours or human capital than the rents shared by company. In the benchmark estimation, I measure labour with normalized wage bill, $\frac{W_{ij}L_{ij}}{\sum_r W_{ij}L_{ij}} L_r^i$, to control for the labour heterogeneity within the region. In a robustness test, I also measure labour simply using employment. Labour between regions is perfectly substitutable in the same sector. This is not an irrational surmise. Although the labour in Eastern regions could be better educated than those in the West, the gap should not be wide especially for the manufacturing sectors. Western workers are considered more hardworking than those from the East. The longer working hours may fill in the small gap in quality. Workers are also assumed to substitute across sectors. Labour differentials across sectors are simply ignored, which might overestimate the labour distortion across sectors.

Regions are defined as 31 officially classified provinces excluding Hong Kong, Macau and Taiwan. Segment category is the combination of 5 ownership types, urban/rural classification and big/small firm size. Ownership includes state-owned, collective, private, foreign-funded companies and Hong Kong, Macau and Taiwan (HMT) joint ventures. Urban and rural classification depends on the administrative division. All the counties are regarded as rural because of the high proportion of agriculture population while the other county-level cities and municipal districts are treated as urban. Big firms have the capital stock higher than the median in 4-digit industries. Observations are categorized in 425 4-digit CIC sectors in 2007. 2-digit CIC aggregation can further reduce the number of sectors to 30.

⇒ Insert Figure 1 approximately here ⇐

Figure 1 illustrates the input allocations by different firm types over the period. Figure 1(a) shows that most of the new jobs in manufacturing sectors are located in the Eastern region that includes all the coastal provinces, whereas manufacturing employment slightly drops in Northeast, Middle and West. Since firms in the Eastern regions are considered to have the highest labour productivity in the country, labour migration from inland to coastal provinces could have mitigated distortions across regions and promote the overall economic growth. Figure 1(b) shows that capital accumulation slightly rises for state-owned firms but declines for collective companies. In contrast, private and foreign investment has experienced huge development. In 1998 SOEs dominate the economic activities with 64% of total accumulated capital and 58% of total employment while in 2007 state-owned, collective/private, and foreign/HMT firms possess 45%, 21% and 34% of total capital respectively and each provide about one-third of total employment. The increase of private businesses is partly related with the privatization of SOEs. Lower proportion of inefficient state-owned firms in economy could have improved the resource allocations across ownership. Figure 1(c) shows that urban firms account for about 84% of total capital in manufacturing sectors with 73% of total observations. Big firms provide 80% employment but 96% capital stock in total manufacturing. This might be associated with the investment policies biased toward big urban companies. Allocative distortions arise when big differentials in productivity exist between firms with different size in urban or rural areas. Figure 1(d) shows that capital accumulation in metallurgy and equipment manufacturing is more than 30% faster than the other industries in the period, i.e. metallurgy of 131%, equipment of 132% vs. chemistry of 99% and the other manufacturing of 91%. Excessive financing support could create over-capacity and lower productivity in those selective sectors. In section 5, I will investigate the differentials in marginal products of input across 2-digit manufacturing sectors.

4 Distortion decomposition

Figure 2(a) displays aggregate output gains (in log-points) associated with eradication of total labour or capital distortions and full liberalization of both inputs over time. Overall distortion drops dramatically in the beginning years and rise slightly at the end of period. Eliminating total labour and capital distortions both significantly boost aggregate output while the contribution of total labour distortion is a bit higher than that of total capital distortion. Figure 2(b) and 2(c) plot the decomposition of total labour and capital distortions over time. Each component of distortion is measured as its contribution to the actual aggregate output. The cost measures exhibit the same evolution patterns but in slightly lower magnitude for within-sector distortions. Both measures coincide for cross-sector distortions.

⇒ Insert Figure 2 approximately here ⇐

4.1 Misallocation within Sectors

Hsieh and Klenow (2009) find that TFP gains (in change-ratios) of a full liberalization within industries of China drop from 115.1% in 1998 to 86.6% in 2005, which gives an allocative efficiency improvement of 15% (2.115/1.87), or 2% per year. I extend the data to ten years' period and obtain TFP gains of eliminating all within-sector distortions about 50% higher than reported by Hsieh and Klenow (2009), i.e. 169% in 1998, 130% in 2002, 134% in 2005, and 141% in 2007. These differentials in TFP gains are probably ascribed to different industry composition or data truncation for measurement errors. My results also infer 15% (2.69/2.34) within-sector allocative efficiency improvement from 1998 to 2005 but reveal a rise of TFP gains after 2002.

Figure 2(b) shows the evolution of labour distortions between and within regions in the industries. In contrast to the between-region curve, idiosyncratic labour distortion within regions is more than three times as large. Its reduction is slightly larger than the fall of between-region distortion over the period, i.e. 6.3% vs. 5.5% in contribution measures. However, within-region labour distortion exhibits a stable climbing after 2002 following a big drop in the first year. Between-region labour distortion takes a persistent downward trend which is flattening after 2005. Population movement from interior to coastal provinces has continuously reduced the labour distortion across regions. This might also be associated with the national "West Development Strategy" published in the late 1990s to lessen regional imbalance in labour and capital productivity. Further labour migration is meaningful as the between-region labour distortion at the end of period is still significant, i.e. 9.1% in cost measure and 11.5% in contribution measure. In addition, the greater TFP gain is able to be achieved by exploiting the big rising within-region labour distortion. As τ^l_{ij} also captures policy distortions on output markets, this might be associated with the more government intervention in production.

Figure 2(c) depicts capital distortions between and within segments in the industries. Idiosyncratic capital distortion within segments accounts for more than two-thirds of total capital misallocation but the improvement of between-segment capital allocation contributes to most of the capital distortion reduction between 1998 and 2007. Within-segment capital distortion slightly increases while between-segment capital distortion is roughly reduced by half in the decade. Deepening reforms of the financial system, i.e. privatizing state-owned banks and developing stock and bond markets, are targeting for a more efficient capital market where the gap of financing costs shrinks across firms of different types. The improvement of capital mobility across segments is still important as in 2007 between-segment capital distortion is 7.3% in cost measure and 7.9% in contribution measure. Moreover, capital reallocation within segments might provide more potential gains, e.g. the interprovincial imbalance of capital accumulation and efficiency.

I perform three robustness checks on the distortion decompositions. All these robustness checks confirms rising idiosyncratic distortions and falling systematic distortions within the sectors. In the end of data period, great economic growth is still able to be achieved by eliminating the existing systematic distortions. Figure 3(a) and 3(b) illustrate the evolution of systematic distortions within sectors for each robustness check.[16]

⇒ Insert Figure 3 approximately here ⇐

The framework of Hsieh and Klenow (2009) is vulnerable to measurement error. To get rid of the possible outliers that enlarge the return dispersions within each industry, in the benchmark results I trimmed top and bottom 1% tails of MRPL, MRPK and TFPR which add up to 6% of total observations. Doubling the data truncation to 2% tails or 12% of observations lowers the total TFP gains from 169% to 112% in 1998 and from 141% to 105% in 2007. Data of 1998 might have greater measurement errors in the remaining 1% tails than the other years. More importantly, the evolution of the distortions does not differ from the benchmark results. Most of the reductions in TFP gains are reflected in the idiosyncratic distortions. Idiosyncratic distortions are reduced by about one-fifth but also show a rebound after 2002. The gains of eliminating systematic distortions within sectors still follow a clear downward trend and end with 9.3% for labour and 6.4% for capital in contribution measures.

To control for the labour heterogeneity within industries, I measure labour as the normalized wage by assuming that the wage per worker differs only because of the work hours and human capital. However, the more productive firms might be willing to share the rents with workers and pay higher wages. Therefore, the benchmark results might be underestimating the dispersion of marginal product of labour. Simply using employment as the measure of labour input indeed raises the labour distortions. Since I assume the perfect substitution of labour across regions, all the additional labour heterogeneity is added into the idiosyncratic labour distortions within regions. Aggregate TFP gains of eliminating overall distortions decline from 197% in 1998 to 162% in 2007, about 20%-30% higher than the benchmark results. Neglecting the labour heterogeneity amplifies the idiosyncratic labour distortion but still generates a similar pattern of evolution for all distortion components.

I assume a constant elasticity of substitution for all industries, $\sigma = 3$. Hsieh and Klenow (2009) address that this is conservatively at the low end of empirical estimates

[16]Table A.1 in the appendix reports the full results of the distortion decomposition for baseline model and three robustness checks.

and when σ is higher, productivity dispersions are closed more slowly in response to the efficient reallocation, enabling bigger gains from eliminating distortions. Full liberalization TFP gains under $\sigma = 5$ skyrocket from 169% to 312% in 1998 and from 141% to 242% in 2007. All labour and capital distortions soar as well by more than a half over the benchmark results. In 2007, the contribution of within-sector systematic distortions is 17.8% for labour and 13.5% for capital.

Brandt et al. (2013) report the opposite findings that capital distortion between state and nonstate sectors increases and labour distortion across provinces does not decline after 1998. However, they make a strong assumption that all the sectors use the same production technology. As SOEs might have been shifting toward capital-intensive industries within the manufacturing sector (Song et al., 2011), their result is likely to underestimate the capital productivity of state sector and thereby overestimate the capital market distortions in the recent years. In addition, they use aggregate non-agricultural data and argue that the industry composition of the state sector has become slightly more labour intensive. But the rising labour shares of the state sector actually stem from health, education and government sectors rather than the manufacturing sectors.

4.2 Misallocation across Sectors

Figure 2 also measures the labour and capital distortions across sectors. They reflect the inter-sector reallocation effects on aggregate output when industrial average marginal revenue products of labour or capital are equalized. Since TFP of individual firms is assumed to be exogenous in the model, aggregate TFP of each industry is not affected by the distortions across sectors. However, in reality, capital distortions across sectors could arouse over-capacity and lower TFP of the firms in some industries. Therefore, taking individual productivity as an exogenous variable in the model is likely to underestimate the reallocation effect across sectors on the aggregate output.

The evolution of cross-sector capital distortions reveals a limited improvement of capital misallocation across sectors, i.e. 2.3% reduction from 1998 to 2007. Empirical studies that investigate inter-sector reallocation effects in the real aggregate productivity growth confirm the poor improvement of capital misallocation across sectors in China's industrial growth, e.g. Lin and Ge (2012) and Lu (2002) using the strategy of Syrquin (1984). More importantly, capital distortion across sectors even has higher magnitude than between-segment capital distortion within sectors at the end of period, i.e. 10.9% vs. 7.9% in contribution measures. Excessive investment directed by the government over selected sectors has negative impacts on inter-sector allocative efficiency. Large capital distortions across sectors raise the importance of formulating policies to improve the capital mobility across sectors, i.e. reducing the role of government in financing manufacturing industries.

Less than 1% reduction is found for labour distortions across sectors over the period. Distortion measures have modest magnitude, i.e. 8.2% in 2007. However, I do not emphasize this source of misallocation based on two counts of concerns. First, as industries cluster across provinces, labour distortion across sectors would mix up with part of regional dispersions in labour productivity. This issue is less severe for capital as most of the manufacturing sectors are open to alternative ownership. Second, industries require different labour skills. Failure to identify the labour heterogeneity across sectors would also overestimate the sectoral distortions on labour.

The robustness checks in the previous section hardly affect the distortions across sectors. They are more sensitive to the Cobb-Douglas aggregation of sectoral outputs. However, unobserved demand factor κ_i no longer cancels out in the change of CES aggregations. Following Hsieh and Klenow (2009), here I ignore this cross-sector variations and simply set $\kappa_i = 1$ for all the sectors. Suppose that final good is a CES aggregate of sector outputs:

$$Y = \left(\sum_{i=1}^{N} \theta_i Y_i^{\frac{\phi-1}{\phi}} \right)^{\frac{\phi}{\phi-1}}$$

When sector outputs are more complementary ($\phi = 0.5$), the contribution of capital distortion across sectors becomes much smaller, i.e. 5.5% vs. 10.9% in 2007. Sectors with high productivity obtain less capital in the reallocation. When sector outputs are more substitutable ($\phi = 1.5$), the contribution of capital distortion across sectors becomes much larger, i.e. 16.6% vs. 10.9% in 2007. Since sector outputs are better substitutes, more capital is reallocated toward the sectors with high productivity. CES aggregator of sector outputs does not alter aggregate TFP gains of each industry. Within-sector distortion measures slightly differ with the new cross-sector allocative equilibrium.

4.3 Comparison with EU-15

Another robustness check is to apply the same method on the developed countries that are supposed to have less distortions on both product and factor markets. Brandt et al. (2013) find that between-state distortions in the United States is significantly smaller than between-province distortions in China. I compare my results of China with the decomposed distortions in EU-15 countries.[17]

I extract all manufacturing firms in EU-15 countries from Amadeus database that includes comprehensive company information across Europe. After trimming observations

[17] EU-15 refers to the first 15 Member States of the European Union before the new Member States joined the EU after 2004. The 15 Member States are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

with missing value in fixed assets, employment, wage bill and value-added, I obtain the number of firms increasing from over 168,000 in 2002 to about 282,000 in 2011. Nominal aggregate value-added grows 4.25% per year in the ten years' period. Sectors are defined at 4-digit NAICS.

Country/territory is the most important segment in EU labour market. Cultural and language differences are major causes of worker immobility across borders. National systems that safeguard employment, e.g. long-term unemployment benefits, early retirement packages, subsidized career break schemes and so on, encourage employees to stay put in the country rather than looking for outside job. Benefits of purchasing houses with tax breaks, interest subsidies and premium, and indirect tax of property sales provide other disincentives to moving out of the country. With regard to capital segment, I combine five types of ownership and four firm size categories. Amadeus database defines the ultimate owner as the largest owner in a firm with total or direct ownership of over 25%. Following OECD (2006), I make a distinction of five different types of ultimate owners: (i) state, when the ultimate owner is government or a public authority; (ii) family, when the ultimate owner is either a family or an individual; (iii) industrial company; (iv) financial company, when the ultimate owner is either a financial institute, an insurance company, or a bank; and (v) other, when the ultimate owner does not exist or is one of the following: employees/managers, foundation, or mutual pension fund/trust. All firms in Amadeus are categorized into 'very large', 'large', 'medium sized' and 'small' groups, which account for 3%, 13%, 37% and 47% of total observations respectively.

The contemporary total aggregate output gain due to distortions in EU-15 manufacturing is only 50%-60% of that in China. The decomposition of labour and capital distortions in EU-15 is reported in figure 4. Labour distortion across countries in EU of more than 25% is much larger than the between-province distortions in China (11.5%-17%). Moreover, it turns out to uprise after 2007. Manufacturing sectors in Southern Europe might have suffered more in the global economic downturn. However, labour distortion within countries contributes only about 5% of aggregate output loss and is roughly stable over time. Figure 4(b) indicates that capital distortions across firm segments and across sectors in Europe are significantly smaller than in China as expected. Both distortions exhibit comparable magnitude persistently over the period. Eliminating each systematic capital distortions only promotes the aggregate output by nearly 4%.

⇒ Insert Figure 4 approximately here ⇐

5 Policy Implication

Decomposition of total factor market distortions across different dimensions brings forward important policy implications. In the previous section, distortion measures strongly suggest further improvement of labour mobility across regions and capital mobility across segments and across sectors. Figure 5 reports the potential aggregate output gains in change-ratios associated with systematic and overall distortions. Over one-fifth of counterfactual aggregate output growth in efficient factor allocation can be achieved by reducing three systematic distortions. Labour distortion across regions and capital distortions across segments and across sectors account for 38%, 26% and 36% of overall systematic distortion in 2007. F-tests in a three-way factorial ANOVA of firms' marginal products significantly reject the null hypothesis that the means of labour and capital return are equal between sectors, regions or segments. In this section, I investigate dispersions in average marginal products of labour and capital across these three dimensions and evaluate the potential room to enhance the economic growth.

⇒ Insert Figure 5 approximately here ⇐

Hsieh and Klenow (2009) set constant return to scale production. The availability of rich firm-level panel data makes it possible to estimate marginal products of labour and capital more accurately with semi-parametric production estimators, e.g. Olley and Pakes (1996), Levinsohn and Petrin (2003), Ackerberg et al. (2006), and Wooldridge (2009). They control carefully for the simultaneity and selection bias with proxy variables, i.e. investment and intermediate inputs, in estimating productivities. Alternative production estimations might result in quite different marginal products. For instance, food and timber manufacturing could be more capital-intensive in US than in China. Assuming the same technology and using the average labour share of US could overestimate the capital productivity in China. Henceforth I compare the marginal products estimated by the approach of Ackerberg et al. (2006). Ackerberg et al. (2006) suggest a more solid identification. Labour and capital coefficients are both recovered in the second stage using a GMM estimator.

⇒ Insert Figure 6 approximately here ⇐

Figure 6 demonstrates the development of the coefficient of variation for the marginal products of labour and capital across provinces, firm segments and 2-digit industries. The results are quite in line with the evolution of systematic distortions in figure 2. Dispersions in labour and capital returns across regions and segments decline by more than 30% while the reduction of return variations across sectors is much less.

Between-region labour distortion has been dramatically reduced by the enormous inter-province migrant flows.[18] Figure 1(a) shows that manufacturing sectors in coastal provinces provide 91% more job positions in 2007 compared to 1998 while the according employment in the other regions slightly drops by 3%. However, the inland provinces are quickly catching up in terms of labour productivity. Table 2 lists the average marginal products of labour and capital for all 31 provinces. Marginal products of labour in Beijing, Shanghai and Guangdong[19] grew 264%, 246% and 111% respectively in the period 1998-2007 while some migrant-exporting provinces increased their marginal products by more than four times, e.g. Anhui for 490%, Henan for 627%, and Sichuan for 483%. In 2007 Beijing and Shanghai still had a labour productivity 10-20% higher than the other provinces. The congestion of labour-intensive sectors with slow efficiency improvement in Guangdong and Zhejiang provinces makes labour productivity below the national average. New migration policies are required to attract the labour-intensive manufacturing and workforce towards Central and Western provinces with relatively high labour productivities, such as Anhui, Henan, Sichuan and Yunnan.

⇒ Insert Table 2 approximately here ⇐

Despite the reduction of between-region capital return dispersion shown in Figure 6, capital productivities in Beijing, Shanghai and Guangdong become 10-50% lower than the national average in 2007. Capital accumulation in those three provinces accounts for 21% of national total. Easy access to the local financing channels might have caused abuse of capital in manufacturing. State-dominated banks could be advised to enlarge the interprovincial credit grants for provinces with high capital returns, e.g. Henan, Yunnan and Guangxi.[20]

Between-segment capital distortions have been slackening during the economic transformation. Table 3 lists the average marginal products of labour and capital for firm segments. In 1998 marginal products of capital in state-owned enterprises were approximately half of the capital productivity in private, collective and foreign companies. Nine years later state-owned plants have become only 20-40% less efficient in capital than private and collective firms and make no clear difference with foreign joint ventures including those funded from Hong Kong, Macau and Taiwan. Capital in rural regions has 10-30%

[18]National Bureau of Statistics of China reports that population of migrant labour exceeds 250 million in 2011.

[19]Beijing, Shanghai, and Guangdong are the representative municipalities/province for Bohai bay economic rim in North China, Yangtze river delta in East China and Pearl river delta in South China.

[20]Table A.2 in the appendix reports the average marginal products in 2007 for all the provinces with different production estimators.

higher return than the urban investment for state-owned, collective and private businesses. Great disparity of capital returns still remains in firm size. Small companies are more than twice as efficient as big competitors in all five types of ownership. Reversing the entrenched investment policies that are biased towards large urban SOEs needs to be the key objective in the reforms of financial sectors. Development of small loan businesses could offer more means of financing for small private companies in rural regions.

⇒ Insert Table 3 approximately here ⇐

SOEs also catch up with foreign firms in terms of labour productivity and surpass collective and private companies on average from 1998 to 2007. The difference in marginal products of labour between urban and rural areas is small. State-owned or foreign firms have higher labour returns in cities while rural workers are slightly more productive in collective or private companies. In contrast to the findings regarding capital productivity, small manufacturers are 20-50% less efficient in labour than the big firms. As also explained by Qian and Zhu (2013), difficulties in financing force those small private businesses to employ more workers that substitute for capital and thereby lower the marginal products of labour.[21]

Table 4 lists the average marginal products of labour and capital for all 2-digit industries. Industries with high capital productivity include tobacco, food processing, textile, electrical machinery and waste materials recycling. Manufacturing of general and professional equipment, communication device, instrument, paper and printing have low productivity of capital. Among them, communication device production such as television and computer experienced a rapid capital accumulation of 322% growth for the period 1998-2007 but suffer with one of the lowest marginal products of capital. Over-investment in those sectors is blamed on the excessive financing support by the state-dominated banks and local governments. Demand suppressed by the inferior techniques finally results in the over-capacity in production. This is not the unique case. For instance, steeling and photovoltaic industries acquired excessive capital from government stimulus in the global economic turmoil and have confronted serious capacity plethora when demand restores or faces new trade barriers.[22] Recently, the old television lesson repeats for LED. Large amount of government-backed loans are invested in the capacity of outdating techniques while international competitors such as Samsung and Sony start mass production of televisions with a new generation of techniques. Governments should definitely give up these

[21] Table A.3 in the appendix reports the average marginal products in 2007 for all the segments with different production estimators.

[22] US has been imposing 31%-250% anti-dumping duties on photovoltaic (PV) from China since May 2012. EU launched Chinese anti-dumping PV investigation in September 2012.

inefficient financing support and gradually liberalize banks with autonomous interest rates on both deposit and credit.

⇒ Insert Table 4 approximately here ⇐

Product per worker also deviates across sectors. This reflects more than the sectoral differentials in labour quality as the marginal product of labour in the least productive sectors are less than doubled on average in the decade while labour in the most productive sectors has become over four times more productive in the same period. However, different requirement of labour skills across sectors installs barriers for labour mobility. The tobacco industry has high marginal products in both capital and labour. Metallurgy and petrochemical have relatively high labour productivity. Resources moving to those sectors must also be restrained in the light of negative externalities, i.e. increasing public health care expenditure, high pollution and energy consumption.[23]

⇒ Insert Table 5 approximately here ⇐

Table 5 reports the potential increase in total manufacturing value-added of the counterfactual factor reallocations. I only estimate the impact of small percentage factor reallocations as marginal products may stay roughly constant.[24] The top panel of Table 5 simulates the regional reallocation baselined in 2007. Moving 1% manufacturing labour out of Guangdong and Zhejiang to selective Central and Western provinces boosts the total manufacturing GDP by 0.05%. An inland shift of labour-intensive sectors would slow down the inefficient coastal labour migration and have positive impacts on local economic development. Keeping production within China's borders also avoids decamping of international manufacturers and encourages the industrial upgrading in coastal regions. A better restructuring of 1% labour from 5 lagging provinces to 5 leading provinces provides a potential output growth of 0.12%. Shifting 1% capital of Beijing, Shanghai and Guangdong to Henan, Yunnan and Guangxi improves the capital efficiency and gives rise to a 0.04% growth of GDP in manufacturing. Moving 1% capital out of 5 lagging provinces to 5 leading provinces arouses weaker contribution as the lagging provinces in Northwest and Northeast possess much less capital in manufacturing than those three capital abundant provinces.

[23]Table A.4 in the appendix reports the average marginal products in 2007 for all the sectors with different production estimators.

[24]For a gross output production function, we also need to consider the differentials in demand elasticities across sectors. The ideal movement would be to attract the resources from less productive inelastic sectors to more productive elastic sectors. Less productive sectors produce less but the price increase will compensate as much. Sectors that are more productive can produce more with unchanged prices.

The middle panel discloses the impact of segmental reallocations between ownership, level of urbanization and firm size. Sending 1% of production capacity from state-owned enterprises to collective and private companies, from urban to rural plants, and from large to small firms yields gains in aggregate value-added of 0.02%, 0.01% and 0.18% respectively. Considerable impacts from firm size confirm the importance of developing small credit markets. Improvement of disparities in ownership and between urban and rural areas could additionally deliver equally important social consequences since large inequalities are a potential source of social conflict and instability (Zhang and Tan, 2007).

The bottom panel in Table 5 evaluates four scenarios of sectoral reallocation. Moving 1% labour out of textile and small commodities and distributing proportionally according to value-added among food and beverage manufacturing could increase manufacturing GDP by 0.1%. Compared to the other sectors with high labour productivity such as metallurgy and pharmaceuticals, food and beverage manufacturing have low demand for labour skills. Reallocating low-skill workforce between those labour-intensive sectors is relatively easy to realize. Moving 1% labour out of 5 lagging sectors to 5 leading industries increases more value-added but requires extra social costs to retrain workers. Divesting 1% capital out of over-invested sectors, i.e. equipment and communication device manufacturing, to electrical machinery and waste materials recycling increases aggregate value-added by 0.09%. Capital is largely injected into fixed assets and becomes stubborn to shift among sectors. Electrical machinery and waste materials recycling are likely to share part of the production techniques, materials and machinery with those inefficient sectors and are able to absorb some of the over-capacities. Moving 1% capital out of 5 lagging sectors to 5 leading industries is therefore rather theoretical and raises manufacturing GDP by 0.1%. Divesture of inefficient sectors is however belated effort. Government must reduce its role in financing manufacturing sectors to fundamentally improve the capital mobility across sectors.

6 Conclusion

In this paper, I decompose firm-level distortions in China's manufacturing sectors into systematic components, i.e. labour distortion across regions, capital distortions across segments and across sectors, and idiosyncratic residuals. In the framework of Hsieh and Klenow (2009), an extended model suggests that most of allocative efficiency gains within manufacturing sectors are associated with the reductions of labour distortions across regions and capital distortions across segments from 1998 to 2007. Improvement of misallocation across sectors is limited. Rising idiosyncratic distortions after 2002 are responsible for the setback of total allocative efficiency over time. Systematic distortions across regions, segments and sectors are still significant in 2007 and provide great potentials for economic growth.

Those findings are robust to alternative measurement error corrections, labour heterogeneity across firms, and aggressive elasticity of substitution in monopolistic competition. However, some caveats for the limits of the model must be added. First, existing measurement errors might still overstate the distortions, despite the evidence provided by Hsieh and Klenow (2009) to reassure that remaining measurement errors in China's manufacturing microdata do not account for big TFP gains. Second, unit elasticity of substitution across sectors constrains the sectoral reallocation to estimate distortions across sectors, although it is not rejected in Chinese data. Third, policy distortions and impact of entry and exit are not separately taken into account.

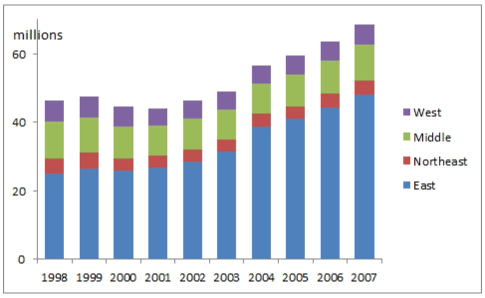
Counterfactual policy simulations across regions, segments and sectors suggest that reallocating labour among labour-intensive sectors and transferring those sectors from coastal regions, i.e. Zhejiang and Guangdong, to selective Central and Western provinces could achieve modest increases of GDP in manufacturing. In terms of capital reallocation, the government must reduce its role in financing manufacturing sectors and avoid the abuse of capital in metropolitan areas. Restructuring the financial system that is biased towards big state-owned urban firms might result in considerable economic growth, which gives rise to the urgence of developing small credit markets.

Table 1: Summary statistics on data sample in manufacturing sector

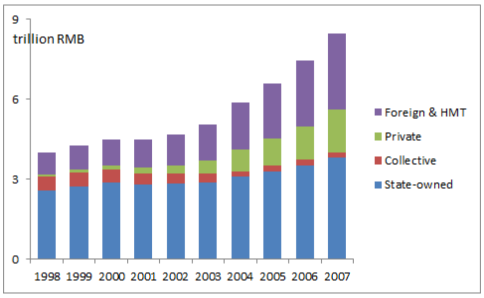
Year	Number of firms	Value Added	Output	Employment	Net value of fixed assets
1998	149,692	1.52	5.96	46.32	4.02
1999	147,116	1.71	6.57	47.61	4.26
2000	148,277	1.99	7.55	44.47	4.48
2001	155,409	2.21	8.52	44.11	4.50
2002	166,868	2.66	10.36	46.17	4.69
2003	181,186	3.41	13.20	48.84	5.04
2004	256,026	4.40	17.05	56.61	5.89
2005	251,499	5.41	20.41	59.35	6.58
2006	279,282	6.74	25.23	63.47	7.44
2007	313,048	8.34	31.55	68.56	8.48

Notes: The unit is trillion RMB for the values and millions of workers for employment

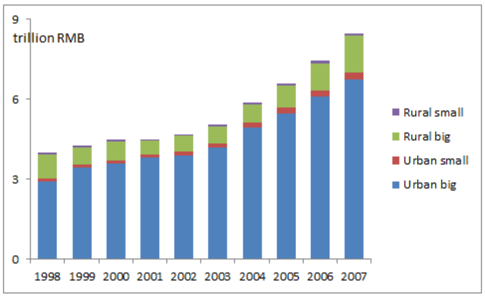
Figure 1: Input allocation by firm type



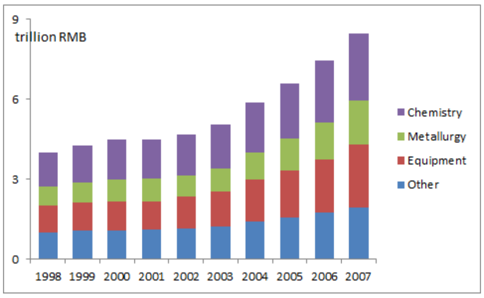
(a) Employment by region



(b) Fixed capital by ownership

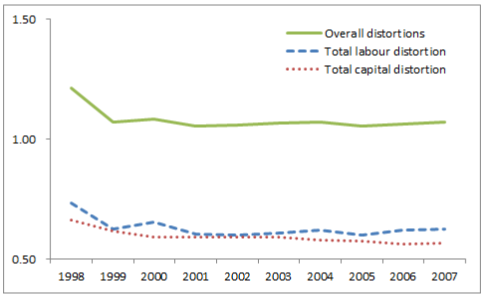


(c) Fixed capital by level of urbanization and firm size

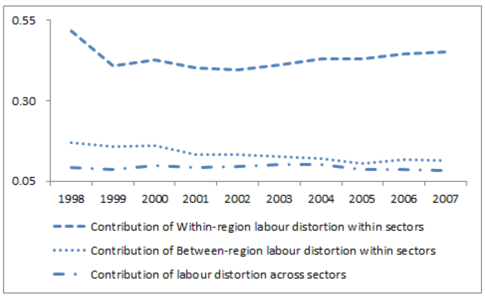


(d) Fixed capital by industries

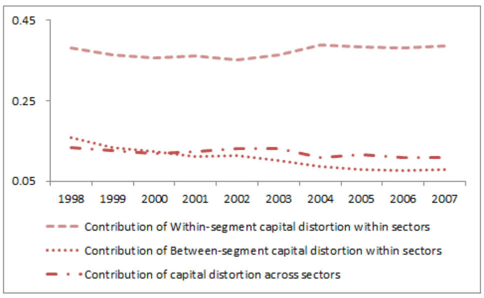
Figure 2: Decomposition of distortions over time



(a) Aggregate distortions

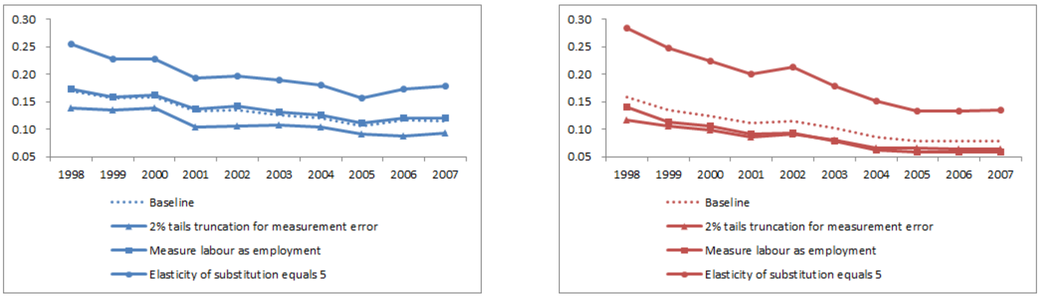


(b) Decomposition of labour distortion



(c) Decomposition of capital distortion

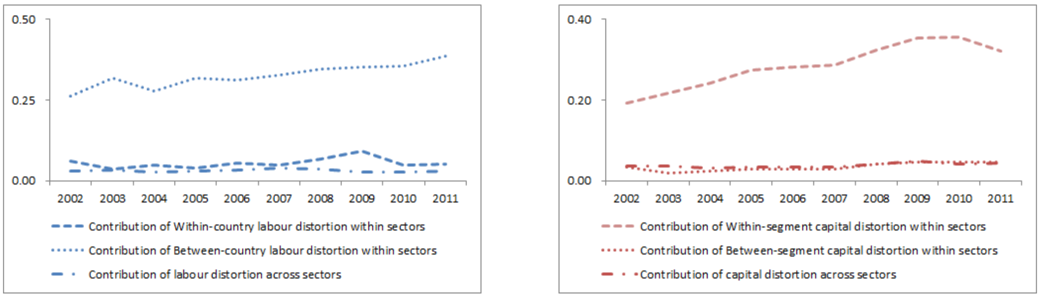
Figure 3: Robustness checks of systematic distortions within sectors



(a) Between-region labour distortion within sectors

(b) Between-segment capital distortion within sectors

Figure 4: Distortion decomposition of manufacturing in EU-15



(a) Decomposition of labour distortion in EU-15

(b) Decomposition of capital distortion in EU-15

Figure 5: Growth potentials in aggregate output

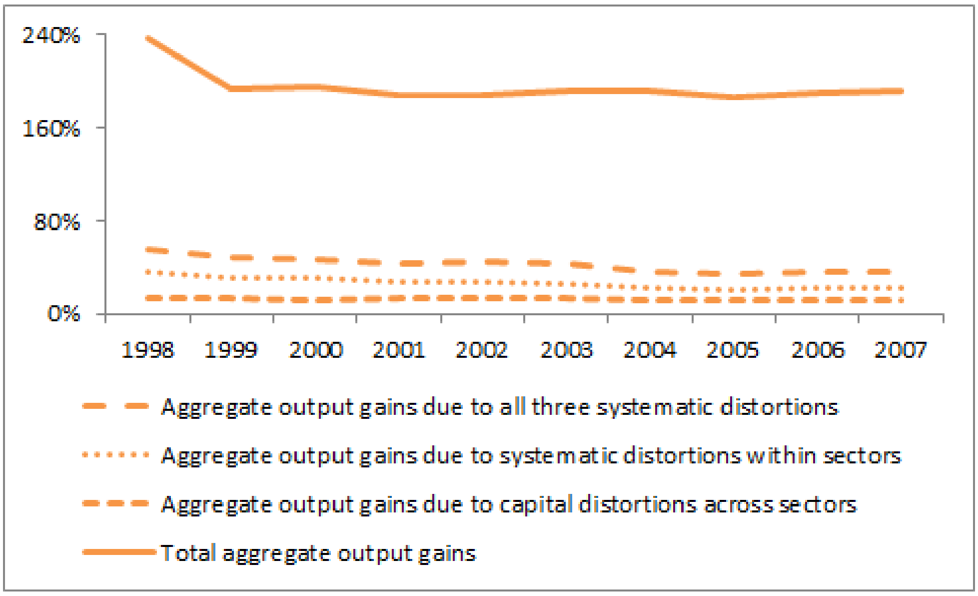
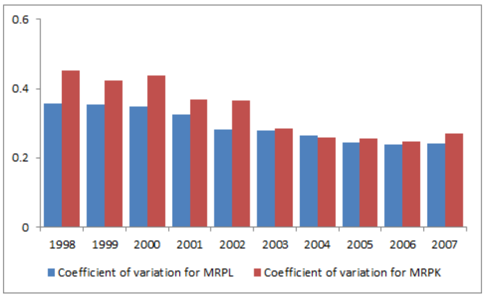
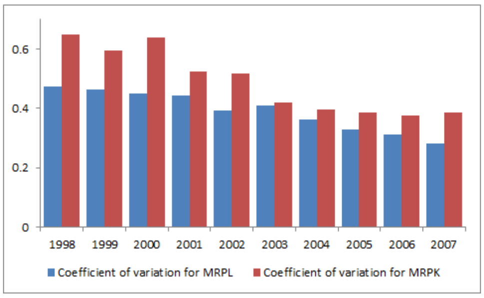


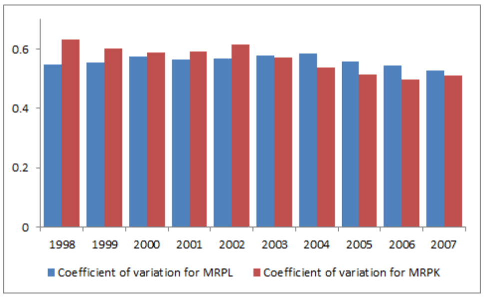
Figure 6: Coefficient of variation for MRPL and MRPK across regions, segments and sectors



(a) Coefficient of variation across regions



(b) Coefficient of variation across segments



(c) Coefficient of variation across sectors

Table 2: Average Marginal Products for all provinces

province	Value-added in 2007 (billion RMB)	MPL 1998	MPL 2003	MPL 2007	MPK 1998	MPK 2003	MPK 2007
11 - Beijing	151	19	48	69	0.03	0.08	0.10
12 - Tianjin	202	13	30	71	0.01	0.12	0.23
13 - Hebei	326	11	27	56	0.10	0.19	0.28
14 - Shanxi	125	8	15	36	0.05	0.09	0.16
15 - Inner Mongolia	129	8	28	82	0.05	0.11	0.24
21 - Liaoning	403	8	26	66	0.05	0.11	0.22
22 - Jiling	143	12	39	80	0.07	0.18	0.25
23 - Heilongjiang	75	8	22	41	0.04	0.09	0.14
31 - Shanghai	462	23	57	79	0.06	0.12	0.17
32 - Jiangsu	1073	14	35	60	0.07	0.14	0.19
33 - Zhejiang	614	15	26	36	0.07	0.14	0.17
34 - Anhui	183	10	26	58	0.10	0.18	0.26
35 - Fujian	284	18	27	38	0.12	0.14	0.27
36 - Jiangxi	137	8	22	56	0.06	0.16	0.31
37 - Shandong	1125	12	31	67	0.12	0.21	0.29
41 - Henan	460	9	20	64	0.11	0.19	0.37
42 - Hubei	236	14	28	57	0.09	0.10	0.20
43 - Hunan	215	10	25	55	0.07	0.13	0.27
44 - Guangdong	1087	20	34	43	0.08	0.12	0.18
45 - Guangxi	111	10	22	57	0.07	0.11	0.35
46 - Hainan	20	22	43	119	0.08	0.13	0.21
50 - Chongqiang	103	8	25	50	0.02	0.11	0.19
51 - Sichuan	283	10	26	57	0.05	0.13	0.23
52 - Guizhou	51	6	15	38	0.11	0.16	0.27
53 - Yunnan	110	21	41	64	0.20	0.25	0.36
54 - Tibet	1	13	26	60	0.09	0.16	0.19
61 - Shaanxi	111	8	19	53	0.03	0.05	0.16
62 - Gansu	55	8	22	45	0.03	0.08	0.19
63 - Qinghai	15	9	22	47	0.05	0.11	0.20
64 - Ningxia	19	8	21	49	0.07	0.11	0.20
65 - Xinjiang	30	8	27	35	0.06	0.10	0.15

Note: province refers to 2-digit national region classification

Table 3: Average Marginal Products for all segments

segment	Value-added in 2007 (billion RMB)	MPL 1998	MPL 2003	MPL 2007	MPK 1998	MPK 2003	MPK 2007
100	53	6	15	36	0.12	0.21	0.63
101	515	11	24	55	0.07	0.15	0.25
110	150	7	18	42	0.07	0.17	0.43
111	2411	10	30	63	0.05	0.10	0.19
200	19	14	18	38	0.35	0.50	0.93
201	51	13	21	54	0.12	0.20	0.34
210	47	15	20	32	0.28	0.41	0.53
211	186	15	27	51	0.11	0.19	0.30
300	185	14	20	37	0.22	0.48	0.74
301	505	15	23	52	0.17	0.18	0.29
310	411	16	21	35	0.24	0.36	0.52
311	1110	16	26	51	0.09	0.12	0.22
400	17	19	20	21	0.25	0.45	0.67
401	133	28	28	31	0.09	0.19	0.17
410	58	19	20	25	0.22	0.31	0.50
411	698	23	30	46	0.08	0.13	0.19
500	11	21	18	26	0.20	0.64	0.47
501	151	43	35	52	0.01	0.15	0.13
510	76	22	28	38	0.25	0.36	0.57
511	1551	32	67	82	0.04	0.14	0.18

Note: segment refers to firms of different types.

The first digit indicates ownership: 1-State-Owned 2-Collective 3-Private 4-Foreign 5-HongKong/Macau/Taiwan

The second digit indicates urbanization: 0-Rural 1-Urban.

The third digit indicates firm size: 0-Small 1-Large

Table 4: Average Marginal Products for all 2-digit industries

cic2	Value-added in 2007 (billion RMB)	MPL 1998	MPL 2003	MPL 2007	MPK 1998	MPK 2003	MPK 2007
13 - Agro-food processing	412	20	42	75	0.17	0.34	0.51
14 - Food manufacturing	165	22	40	76	0.14	0.23	0.35
15 - Beverage Manufacturing	167	38	64	112	0.19	0.24	0.38
16 - Tobacco	259	25	47	89	0.49	0.80	1.12
17 - Textile	436	9	18	31	0.10	0.18	0.29
18 - Apparel	201	17	19	30	0.24	0.34	0.46
19 - Leather	131	11	13	19	0.24	0.40	0.52
20 - Timber processing	97	15	23	47	0.11	0.22	0.40
21 - Furniture	57	19	22	31	0.17	0.23	0.30
22 - Paper	155	7	15	32	0.07	0.10	0.14
23 - Printing	61	14	25	38	0.07	0.07	0.09
24 - Stationery & sporting goods	49	14	16	23	0.19	0.25	0.31
25 - Petrochemical	291	18	49	76	0.12	0.20	0.29
26 - Chemistry	646	6	18	43	0.11	0.18	0.30
27 - Pharmaceutical manufacturing	203	29	58	96	0.20	0.28	0.33
28 - Chemical fiber	72	17	30	58	0.06	0.10	0.16
29 - Rubber	85	18	35	57	0.13	0.20	0.25
30 - Plastic	190	18	27	42	0.17	0.23	0.38
31 - Non-metallic minerals	430	11	22	48	0.09	0.17	0.27
32 - Ferrous metals	799	19	60	145	0.09	0.20	0.30
33 - Non-ferrous metals	381	17	40	116	0.08	0.19	0.42
34 - Hardware	267	17	30	51	0.18	0.31	0.45
35 - General equipment manufacturing	453	7	17	35	0.04	0.08	0.13
36 - Professional equipment manufacturing	272	6	15	33	0.01	0.03	0.06
37 - Transportation	628	18	46	75	0.17	0.36	0.43
39 - Electrical machinery	537	23	44	70	0.22	0.40	0.61
40 - Communication device	703	38	80	81	0.01	0.05	0.07
41 - Instrument	103	18	37	57	0.06	0.07	0.14
42 - Handicrafts & daily sundries	72	11	14	26	0.21	0.28	0.33
43 - Waste material recycling	14		41	113		0.62	0.77

Note: cic2 refers to 2-digit cic industry classification

Table 5: Counterfactual simulations of factor reallocation baselined in 2007

	Scenario			
Regional Reallocation	Move 1% labour out of Guangdong and Zhejiang to Anhui, Henan, Sichuan and Yunnan	Move 1% labour out of 5 lagging provinces to 5 leading provinces	Move 1% capital out of Beijing, Shanghai and Guangdong to Henan, Yunnan and Guangxi	Move 1% capital out of 5 lagging provinces to 5 leading provinces
Change in total value-added	0.05%	0.12%	0.04%	0.02%
Segmental Reallocation	Move 1% labour and capital out of state-owned firms to collective and private companies	Move 1% labour and capital out of urban to rural plants	Move 1% labour and capital out of large to small plants	
Change in total value-added	0.02%	0.01%	0.18%	
Sectoral Reallocation	Move 1% labour out of textile and small commodities to food and beverage manufacturing	Move 1% labour out of 5 lagging sectors to 5 leading industries	Move 1% capital out of equipment and communication device manufacturing to electrical machinery and waste materials recycling	Move 1% capital out of 5 lagging sectors to 5 leading industries
Change in total value-added	0.10%	0.18%	0.09%	0.10%

A Appendix Table

Table A.1: Full results for the distortion decomposition

Benchmark	Overall TFP gains in ratios	Between-region labour distortion	Within-region labour distortion	Between-segment capital distortion	Within-segment capital distortion	Contribution of between-region labour distortion	Contribution of within-region labour distortion	Contribution of between-segment capital distortion	Contribution of within-segment capital distortion
1998	168.98%	12.41%	47.15%	14.92%	37.29%	16.97%	51.71%	15.81%	38.18%
1999	136.48%	12.77%	38.03%	12.59%	35.50%	15.71%	40.97%	13.40%	36.31%
2000	138.16%	12.95%	39.61%	11.61%	34.91%	15.95%	42.61%	12.37%	35.67%
2001	131.57%	10.94%	37.75%	10.47%	35.49%	13.37%	40.18%	11.20%	36.22%
2002	130.19%	11.29%	37.41%	10.82%	34.56%	13.42%	39.53%	11.44%	35.19%
2003	130.80%	9.70%	38.18%	9.52%	35.79%	12.53%	41.01%	10.21%	36.48%
2004	136.20%	9.05%	40.11%	8.09%	38.51%	12.05%	43.11%	8.56%	38.97%
2005	133.93%	8.08%	40.55%	7.43%	38.00%	10.56%	43.03%	7.93%	38.49%
2006	138.16%	8.71%	41.66%	7.23%	37.60%	11.74%	44.69%	7.78%	38.15%
2007	141.31%	9.11%	42.92%	7.25%	37.98%	11.53%	45.34%	7.94%	38.67%

Trim 2% tails of measurement errors	Overall TFP gains in ratios	Between-region labour distortion	Within-region labour distortion	Between-segment capital distortion	Within-segment capital distortion	Contribution of between-region labour distortion	Contribution of within-region labour distortion	Contribution of between-segment capital distortion	Contribution of within-segment capital distortion
1998	111.96%	10.04%	33.36%	10.76%	30.34%	13.87%	37.20%	11.74%	31.32%
1999	103.38%	10.82%	29.96%	9.57%	30.08%	13.49%	32.63%	10.62%	31.13%
2000	100.47%	11.46%	29.58%	8.94%	28.89%	13.88%	32.00%	9.81%	29.76%
2001	97.45%	8.54%	29.50%	7.87%	30.25%	10.44%	31.40%	8.62%	30.99%
2002	97.54%	9.01%	29.56%	8.31%	28.89%	10.64%	31.20%	9.06%	29.64%
2003	97.90%	8.52%	30.24%	7.02%	29.66%	10.85%	32.56%	7.96%	30.60%
2004	102.71%	8.01%	31.74%	5.86%	31.96%	10.43%	34.16%	6.57%	32.67%
2005	100.52%	7.13%	31.93%	5.86%	31.08%	9.20%	34.00%	6.52%	31.74%
2006	104.72%	6.95%	33.50%	5.78%	31.28%	8.80%	35.35%	6.44%	31.94%
2007	105.02%	7.38%	33.56%	5.89%	31.19%	9.30%	35.48%	6.36%	31.65%

Measuring labour with employment	Overall TFP gains in ratios	Between-region labour distortion	Within-region labour distortion	Between-segment capital distortion	Within-segment capital distortion	Contribution of between-region labour distortion	Contribution of within-region labour distortion	Contribution of between-segment capital distortion	Contribution of within-segment capital distortion
1998	196.86%	13.22%	56.89%	13.51%	39.19%	16.97%	60.65%	14.01%	39.69%
1999	151.60%	13.43%	44.38%	10.81%	37.01%	15.71%	46.65%	11.36%	37.57%
2000	168.94%	13.13%	52.18%	9.97%	36.91%	15.95%	55.01%	10.52%	37.47%
2001	150.94%	10.93%	45.50%	8.61%	36.94%	13.17%	47.74%	9.10%	37.43%
2002	149.26%	10.62%	44.89%	8.96%	35.71%	13.41%	47.67%	9.25%	36.00%
2003	148.90%	9.69%	45.82%	7.60%	36.92%	12.53%	48.66%	7.89%	37.22%
2004	152.54%	9.29%	47.16%	5.80%	39.26%	12.05%	49.92%	6.15%	39.61%
2005	150.27%	8.68%	46.52%	5.73%	39.44%	10.56%	48.41%	5.86%	39.57%
2006	149.14%	9.10%	46.32%	5.61%	39.30%	11.74%	48.96%	5.85%	39.53%
2007	162.11%	9.27%	49.42%	5.61%	40.25%	11.53%	51.67%	5.86%	40.50%

Using σ=5	Overall TFP gains in ratios	Between-region labour distortion	Within-region labour distortion	Between-segment capital distortion	Within-segment capital distortion	Contribution of between-region labour distortion	Contribution of within-region labour distortion	Contribution of between-segment capital distortion	Contribution of within-segment capital distortion
1998	311.90%	14.27%	69.77%	21.84%	53.17%	25.44%	80.95%	28.35%	59.68%
1999	237.41%	15.93%	54.50%	17.80%	50.01%	22.72%	61.29%	24.84%	57.04%
2000	242.56%	15.34%	57.04%	16.99%	49.89%	22.73%	64.43%	22.50%	55.40%
2001	230.56%	14.30%	54.59%	14.06%	49.28%	19.25%	59.55%	20.01%	55.23%
2002	224.17%	14.94%	53.37%	13.14%	45.90%	19.69%	58.11%	21.29%	54.06%
2003	228.48%	12.11%	53.73%	11.59%	51.91%	18.95%	60.58%	17.77%	58.09%
2004	233.78%	10.04%	56.53%	9.77%	54.88%	18.12%	64.61%	15.07%	60.18%
2005	227.73%	10.14%	58.14%	8.07%	53.54%	15.68%	63.69%	13.37%	58.84%
2006	234.15%	10.31%	60.64%	8.95%	53.81%	17.39%	67.72%	13.29%	58.15%
2007	241.68%	10.56%	62.71%	8.17%	54.80%	17.84%	69.99%	13.47%	60.11%

Table A.2: Average Marginal Products for provinces in 2007

province	Value-added (billion RMB)	Employment	MPL HK	MPL OP	MPL ACF	Fixed Capital	MPK HK	MPK OP	MPK ACF
11 - Beijing	151	1096427	49	59	69	226	0.11	0.22	0.10
12 - Tianjin	202	1106022	66	80	71	217	0.13	0.30	0.23
13 - Hebei	326	2438988	41	57	56	348	0.18	0.28	0.28
14 - Shanxi	125	1102868	30	45	36	200	0.15	0.18	0.16
15 - Inner Mongolia	129	609730	59	93	82	125	0.26	0.24	0.24
21 - Liaoning	403	2681939	53	65	66	473	0.11	0.28	0.22
22 - Jiling	143	825317	50	75	80	179	0.18	0.27	0.25
23 - Heilongjiang	75	742261	28	44	41	123	0.11	0.16	0.14
31 - Shanghai	462	2780366	64	73	79	592	0.11	0.26	0.17
32 - Jiangsu	1073	8310460	49	56	60	1050	0.13	0.32	0.19
33 - Zhejiang	614	7760474	32	36	36	696	0.12	0.27	0.17
34 - Anhui	183	1379713	40	58	58	193	0.16	0.31	0.26
35 - Fujian	284	3406927	34	40	38	239	0.18	0.36	0.27
36 - Jiangxi	137	1162188	38	51	56	122	0.23	0.32	0.31
37 - Shandong	1125	7342436	49	66	67	990	0.19	0.36	0.29
41 - Henan	460	2856392	49	67	64	322	0.24	0.39	0.37
42 - Hubei	236	1759237	41	58	57	261	0.19	0.26	0.20
43 - Hunan	215	1578944	41	58	55	175	0.23	0.37	0.27
44 - Guangdong	1087	12816720	34	40	43	971	0.15	0.34	0.18
45 - Guangxi	111	854997	40	57	57	98	0.23	0.36	0.35
46 - Hainan	20	87050	67	107	119	31	0.19	0.18	0.21
50 - Chongqiang	103	898015	36	53	50	99	0.21	0.20	0.19
51 - Sichuan	283	1988020	41	63	57	242	0.22	0.32	0.23
52 - Guizhou	51	439005	28	49	38	64	0.20	0.24	0.27
53 - Yunnan	110	565840	42	81	64	106	0.25	0.36	0.36
54 - Tibet	1	10246	30	45	60	2	0.15	0.18	0.19
61 - Shaanxi	111	890016	38	52	53	117	0.16	0.20	0.16
62 - Gansu	55	486115	29	43	45	85	0.18	0.23	0.19
63 - Qinghai	15	100307	46	61	47	26	0.10	0.20	0.20
64 - Ningxia	19	169417	28	44	49	30	0.09	0.20	0.20
65 - Xinjiang	30	309380	27	40	35	72	0.13	0.16	0.15

Note: province refers to 2-digit national region classification

HK estimator uses the production elasticity as in Hsieh and Klenow (2009); OP is the production estimator of Olley and Pakes (1996); ACF is the estimator of Ackerberg, Caves, and Frazer (2006)

Table A.3: Average Marginal Products for segments in 2007

segment	Value-added (billion RMB)	Employment	MPL HK	MPL OP	MPL ACF	Fixed Capital	MPK HK	MPK OP	MPK ACF
100	53	661718	24	35	36	22	0.44	0.71	0.63
101	515	3743286	39	60	55	570	0.18	0.25	0.25
110	150	1668717	31	39	42	47	0.45	0.71	0.43
111	2411	14931050	48	68	63	3158	0.16	0.23	0.19
200	19	214904	30	39	38	5	0.51	1.05	0.93
201	51	409094	42	53	54	43	0.17	0.39	0.34
210	47	612030	27	32	32	15	0.37	0.96	0.53
211	186	1620427	42	48	51	154	0.17	0.39	0.30
300	185	2265139	27	35	37	64	0.37	0.86	0.74
301	505	4264263	38	51	52	440	0.15	0.35	0.29
310	411	5213419	30	34	35	134	0.34	0.92	0.52
311	1110	9715777	42	50	51	948	0.15	0.37	0.22
400	17	403689	18	19	21	5	0.37	0.92	0.67
401	133	1986043	28	31	31	147	0.12	0.28	0.17
410	58	1116976	23	24	25	19	0.33	0.88	0.50
411	698	7448119	39	43	46	770	0.11	0.27	0.19
500	11	207842	22	24	26	4	0.37	0.93	0.47
501	151	1439332	40	48	52	188	0.12	0.24	0.13
510	76	995310	32	35	38	21	0.39	1.02	0.57
511	1551	9638686	60	76	82	1723	0.13	0.28	0.18

Note: segment refers to firms of different types.

The first digit indicates ownership: 1-State-Owned 2-Collective 3-Private 4-Foreign 5-HongKong/Macau/Taiwan

The second digit indicates urbanization: 0-Rural 1-Urban

The third digit indicates firm size: 0-Small 1-Large

Table A.4: Average Marginal Products for all 2-digit CIC industries in 2007

cic2	Value-added (billion RMB)	Employment	MPL HK	MPL OP	MPL ACF	Fixed Capital	MPK HK	MPK OP	MPK ACF
13 - Agro-food processing	412	2648047	34	74	75	288	0.57	0.43	0.51
14 - Food manufacturing	165	1350293	30	63	76	154	0.40	0.31	0.35
15 - Beverage Manufacturing	167	1010217	25	91	112	165	0.50	0.27	0.38
16 - Tobacco	259	186123	71	600	89	89	1.82	1.11	1.12
17 - Textile	436	6262598	31	31	31	486	0.13	0.28	0.29
18 - Apparel	201	4141861	26	23	30	126	0.20	0.51	0.46
19 - Leather	131	2569806	27	30	19	68	0.29	0.54	0.52
20 - Timber processing	97	1100804	53	37	47	78	0.05	0.31	0.40
21 - Furniture	57	913017	34	33	31	49	0.15	0.33	0.30
22 - Paper	155	1383188	29	49	32	251	0.25	0.20	0.14
23 - Printing	61	723825	47	36	38	92	0.06	0.24	0.09
24 - Stationery & sporting goods	49	1199196	17	19	23	39	0.29	0.27	0.31
25 - Petrochemical	291	897964	65	84	76	415	0.32	0.39	0.29
26 - Chemistry	646	3763736	30	67	43	887	0.31	0.26	0.30
27 - Pharmaceutical manufacturing	203	1373407	26	72	96	219	0.46	0.33	0.33
28 - Chemical fiber	72	452981	70	72	58	133	0.12	0.24	0.16
29 - Rubber	85	875062	47	41	57	109	0.13	0.25	0.25
30 - Plastic	190	2240515	34	35	42	195	0.25	0.33	0.38
31 - Non-metallic minerals	430	4484700	39	40	48	580	0.16	0.25	0.27
32 - Ferrous metals	799	3044278	80	111	145	1103	0.24	0.26	0.30
33 - Non-ferrous metals	381	1471115	95	90	116	341	0.22	0.28	0.42
34 - Hardware	267	2734788	45	39	51	209	0.22	0.41	0.45
35 - General equipment manufacturing	453	4207123	51	49	35	358	0.04	0.30	0.13
36 - Professional equipment manufacturing	272	2565101	49	34	33	231	0.05	0.11	0.06
37 - Transportation	628	4188425	57	70	75	629	0.19	0.33	0.43
39 - Electrical machinery	537	4491500	49	60	70	351	0.34	0.50	0.61
40 - Communication device	703	5879179	51	62	81	706	0.10	0.30	0.07
41 - Instrument	103	1069696	45	44	57	73	0.22	0.34	0.14
42 - Handicrafts & daily sundries	72	1260906	22	24	26	44	0.44	0.41	0.33
43 - Waste material recycling	14	66369	119	83	113	6	0.29	0.87	0.77

Note: cic2 refers to 2-digit cic industry classification

B Formula Appendix (Not for Publication)

Average marginal revenue product is defined as $(\overline{MRPL_i})^{-1} \triangleq \sum_j (\overline{MRPL_{ij}})^{-1} s_{ij}$ where $s_{ij} = \frac{P_{ij}Y_{ij}}{P_iY_i}$ is the revenue share. Marginal products and revenue productivities can be written in the function of distortion parameters.

$$\begin{aligned}
\overline{MRPL_i} &\triangleq \frac{1}{\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^l}{W_{r_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}} = 1/\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^l}{W_{r_j}^i} (\frac{P_{ij}}{P_i})^{1-\sigma} \\
&= 1/\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^l}{W_{r_j}^i} \frac{(\frac{(W_{r_j}^i)^{\alpha_i}(R_{s_j}^i)^{1-\alpha_i}}{A_{ij}(1-\tau_{ij}^l)^{\alpha_i}(1-\tau_{ij}^k)^{1-\alpha_i}})^{1-\sigma}}{\sum_{j=1}^{M_i} (\frac{(W_{r_j}^i)^{\alpha_i}(R_{s_j}^i)^{1-\alpha_i}}{A_{ij}(1-\tau_{ij}^l)^{\alpha_i}(1-\tau_{ij}^k)^{1-\alpha_i}})^{1-\sigma}} \\
\overline{MRPK_i} &\triangleq \frac{1}{\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^k}{R_{s_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}} = 1/\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^k}{R_{s_j}^i} (\frac{P_{ij}}{P_i})^{1-\sigma} \\
&= 1/\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^k}{R_{s_j}^i} \frac{(\frac{(W_{r_j}^i)^{\alpha_i}(R_{s_j}^i)^{1-\alpha_i}}{A_{ij}(1-\tau_{ij}^l)^{\alpha_i}(1-\tau_{ij}^k)^{1-\alpha_i}})^{1-\sigma}}{\sum_{j=1}^{M_i} (\frac{(W_{r_j}^i)^{\alpha_i}(R_{s_j}^i)^{1-\alpha_i}}{A_{ij}(1-\tau_{ij}^l)^{\alpha_i}(1-\tau_{ij}^k)^{1-\alpha_i}})^{1-\sigma}}
\end{aligned}$$

$$\begin{aligned}
TFPR_{ij} &\triangleq P_{ij}A_{ij} = \frac{\sigma}{\sigma-1} (\frac{MRPL_{ij}}{\alpha_i})^{\alpha_i} (\frac{MRPK_{ij}}{1-\alpha_i})^{1-\alpha_i} \\
&= \frac{\sigma}{\sigma-1} (\frac{W_r^i}{\alpha_i(1-\tau_{ij}^l)})^{\alpha_i} (\frac{R_s^i}{(1-\alpha_i)(1-\tau_{ij}^k)})^{1-\alpha_i}
\end{aligned}$$

$$TFPR_i \triangleq P_iA_i = \frac{\sigma}{\sigma-1} (\frac{\overline{MRPL}_i}{\alpha_i})^{\alpha_i} (\frac{\overline{MRPK}_i}{1-\alpha_i})^{1-\alpha_i}$$

Derivation of the aggregate TFP for the industry is:

$$
\begin{aligned}
A_i &= \frac{Y_i}{L_i^{\alpha_i} K_i^{1-\alpha_i}} = \frac{\left[\sum_{j=1}^{M_i} \left(A_{ij} L_{ij}^{\alpha_i} K_{ij}^{1-\alpha_i}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}}{\left(\sum_{j=1}^{M_i} L_{ij}\right)^{\alpha_i} \left(\sum_{j=1}^{M_i} K_{ij}\right)^{1-\alpha_i}} \\
&= \frac{\left[\sum_{j=1}^{M_i} \left(A_{ij} \left(\frac{1-\tau_{ij}^l}{W_{r_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{\alpha_i} \left(\frac{1-\tau_{ij}^k}{R_{s_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{1-\alpha_i}\right)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}}}{\left(\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^l}{W_{r_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{\alpha_i} \left(\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^k}{R_{s_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{1-\alpha_i}} \\
&= \frac{\left[\sum_{j=1}^{M_i} \left(A_{ij} \left(\frac{1-\tau_{ij}^l}{W_{r_j}^i}\right)^{\alpha_i} \left(\frac{1-\tau_{ij}^k}{R_{s_j}^i}\right)^{1-\alpha_i}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}}{\left(\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^l}{W_{r_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{\alpha_i} \left(\sum_{j=1}^{M_i} \frac{1-\tau_{ij}^k}{R_{s_j}^i} \frac{P_{ij}Y_{ij}}{P_iY_i}\right)^{1-\alpha_i}} \\
&= \left[\sum_{j=1}^{M_i} \left(A_{ij} \frac{TFPR_i}{TFPR_{ij}}\right)^{\sigma-1}\right]^{\frac{1}{\sigma-1}}
\end{aligned}
$$

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