Economics Letters 138 (2016) 26–29

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

The role of returns to scale in measuring frictions in resource allocation: Revisiting misallocation and manufacturing TFP in China[☆]

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HIGHLIGHTS

- The returns to scale are important in measuring frictions in resource allocation.
- If CRS assumption fails, Hsieh & Klenow's (2009) friction measure is problematic.
- We develop a method to accurately measure distortions using MRPK and MRPL.
- Hsieh and Klenow (2009) overestimate the extent of misallocation in China.
- We find that the extent of misallocation in China is considerably lower.

ARTICLE INFO

Article history:
Received 19 October 2014
Received in revised form
26 August 2015
Accepted 9 November 2015
Available online 27 November 2015

JEL classification:
C49
O11
O47

Keywords:
Misallocation
TFP
Returns to scale

ABSTRACT

This paper extends the study by Hsieh and Klenow (2009) on productivity implication of resource misallocation by relaxing the assumption of constant returns to scale (CRS) for differentiated products. We show that when the CRS assumption fails, measuring frictions in resource allocation by variation in revenue productivity, as proposed by Hsieh and Klenow (2009), overestimates the resource misallocation in China.

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1. Introduction

Hsieh and Klenow (2009) develop a quantitative method to measure the impact of resource misallocation on aggregate total factor productivity (TFP). They measure misallocation by the variance of log *revenue* productivity (the product of physical productivity and the firm's output price, denoted as *TFPR* in their paper). They show empirical evidence that efficient allocation of both capital and labor would have increased China's manufacturing TFP by 87%–115% from 1998 to 2005.

Hsieh and Klenow's results are based on two assumptions. First, they assume CRS for monopolistic competition industries. Second, they assume that China has the same output elasticities of capital and labor as those of the US. However, these two assumptions do not hold in China largely due to the different institutions and market conditions.

In this paper, we extend Hsieh and Klenow's analysis by relaxing the CRS assumption. We show that the resource misallocation could not be effectively measured by the variance of ln (*TFPR*) when the CRS assumption fails. In this case, the variation in revenue productivity captures not only the distortions in capital

☆ We are grateful to conference participants at Shenzhen University, Southwestern University of Finance and Economics, and at the 2012 Annual Meeting of China Economist Society. Gong benefited from supports from National Natural Science Foundation of China (#71273162), Shanghai Shuguang Project (#08SG37), and PCSIRT (#IRT13077). The authors do not have any financial or personal interest in subject matter of this research.

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http://dx.doi.org/10.1016/j.econlet.2015.11.014
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and labor, but also the dispersion of firm-specific productivities. Therefore, using the variance of ln (*TFPR*) to measure misallocation could overestimate its implications on aggregate TFP.

We propose to use marginal *revenue* product of capital (*MRPK*) and marginal revenue product of labor (*MPRL*) to measure misallocations. We show that the extent to which *MRPK* and *MRPL* differ across firms is a better measure of distortions when the CRS assumption fails.

We apply our method to Chinese manufacturing data between 1998 and 2007, two more years of data than that used by Hsieh and Klenow (2009) (their data are between 1998 and 2005). The output elasticities of capital and labor across China's manufacturing industries are estimated using Levinsohn and Petrin's (2003) methodology. The estimation results do not support the CRS assumption. Our results suggest that the resource misallocation is considerably lower.

2. Model

2.1. The environment

The model builds upon Hsieh and Klenow's (2009) by relaxing CRS assumption for monopolistic competition industries. Households are assumed to consume a standard basket of goods (Y), which are produced by a representative firm in a completely competitive market using a Cobb–Douglas production technology:

$$Y = \prod_{s=1}^{S} Y_s^{\theta_s}, \quad \text{where} \sum_{s=1}^{S} \theta_s = 1. \tag{1}$$

Here, Y_s is output in monopolistic competitive industry s, which is a CES aggregate of M_s differentiated products:

$$Y_s = \left(\sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where σ is the elasticity of substitution. The production for product Y_{si} is given by a Cobb–Douglas function of firm TFP (A), capital (K) and labor (L):

$$Y = A_{si} K_{si}^{\alpha_s} L_{si}^{\beta_s}. \tag{3}$$

Different from Hsieh and Klenow (2009), we allow decreasing and increasing returns to scale, thus the sum of output elasticity of capital, α_s, and output elasticity of labor, β_s, may not equal to 1. The firms are heterogeneous in distortions. Distortion that increases the marginal product of capital (labor) relative to output is denoted as $\tau_{K_{si}}$ ($\tau_{L_{si}}$).[1]

2.2. Limitation of TFPR as a Measure of Misallocation

Hsieh and Klenow (2009) show that under the CRS assumption, the *revenue* productivity can be expressed as

$$\begin{aligned} TFPR_{si} &\equiv P_{si} A_{si} = \frac{P_{si} Y_{si}}{K_{si}^{\alpha_s} L_{si}^{1-\alpha_s}} \\ &\propto (MRPK_{si})^{\alpha_s} (MRPL_{si})^{1-\alpha_s} \\ &\propto \left(1+\tau_{K_{si}}\right)^{\alpha_s} \left(1+\tau_{L_{si}}\right)^{1-\alpha_s}. \end{aligned}$$

Here, P_{si} is the price of output Y_{si}; $MRPK_{si}$ and $MRPL_{si}$ denote the marginal revenue products of capital (i.e., $\partial (P_{si} Y_{si}) / \partial K_{si}$) and labor (i.e., $\partial (P_{si} Y_{si}) / \partial L_{si}$), respectively.

The expression above implies that the revenue productivity does not vary across firms within an industry unless firms face capital and/or labor distortions or firms have different marginal revenue products of capital and/or labor. Therefore, the dispersion of $TFPR_{si}$ can be used to measure the extent of misallocation. Hsieh and Klenow (2009) show that the negative effect of distortion on aggregate TFP can be fully captured by the variance of ln ($TFPR_{si}$).

In our generalized setting (i.e., $\alpha_s + \beta_s \neq 1$), the *revenue* productivity, nevertheless, is given by:

$$TFPR_{si} \propto \left[\left(1+\tau_{K_{si}}\right)^{\alpha_s} \left(1+\tau_{L_{si}}\right)^{\beta_s} \right]^{\frac{T_s}{\sigma-1}} \cdot A_{si}^{[1-(\alpha_s+\beta_s)]T_s}, \tag{4}$$

where $T_s = \left[\frac{\sigma}{\sigma-1} - (\alpha_s+\beta_s)\right]^{-1}$.

It is clear that when the CRS assumption fails, $TFPR_{si}$ depends not only on factor distortions, but also on firm productivity, i.e., $TFPR_{si}$ varies across firms even without distortions. Therefore, the variance of ln($TFPR_{si}$) is not a suitable measure for misallocation because it captures both the distortions and the dispersion of firm-level productivity.

2.3. Using MRPK and MRPL to measure distortions

We use the marginal revenue products of capital and labor (*MRPK* and *MRPL*) to accurately measure distortions. This is because that *MRPK* and *MRPL* should be equal across firms within an industry without distortions regardless of the returns to scale. Furthermore, *MRPK* (or *MRPL*) is positively proportionate to capital (or labor) distortion and independent on firm-level productivity. Therefore, the variation in *MRPK* (*MRPL*) is a good measure for capital (labor) distortion.

Industry output can be expressed by a function of industry K_s, L_s and industry TFP (A_s):

$$Y_s = A_s K_s^{\alpha_s} L_s^{\beta_s}.$$

Here, A_s is written as:

$$A_s = \left\{ \sum_{i=1}^{M_s} \left[A_{si} \cdot \left(\frac{\overline{MRPK_s}}{MRPK_{si}} \right)^{\alpha_s} \left(\frac{\overline{MRPL_s}}{MRPL_{si}} \right)^{\beta_s} \right]^{T_s} \right\}^{\frac{1}{T_s}}, \tag{5}$$

where $MRPK_{si} = R \cdot \left(1+\tau_{K_{si}}\right)$ and $MRPL_{si} = \omega \cdot \left(1+\tau_{L_{si}}\right)$; $\overline{MRPK_s} = R \cdot \left(\sum_{i=1}^{M_s} \frac{1}{1+\tau_{K_{si}}} \frac{P_{si}Y_{si}}{P_s Y_s} \right)^{-1}$ and $\overline{MRPL_s} = \omega \cdot \left(\sum_{i=1}^{M_s} \frac{1}{1+\tau_{L_{si}}} \frac{P_{si}Y_{si}}{P_s Y_s} \right)^{-1}$ respectively represent the weighted average marginal revenue products of capital and labor in industry s, and R represents capital rental rate and ω represents wage rate.

If the marginal revenue products of factors are equal across firms, industry TFP becomes:

$$A_s = \left(\sum_{i=1}^{M_s} A_{si}^{T_s} \right)^{\frac{1}{T_s}}. \tag{6}$$

If A_{si}, $MRPK_{si}$ and $MRPL_{si}$ are jointly lognormal distribution, there is a closed-form expression for industry TFP:

$$\begin{aligned} \ln A_s = &\frac{1}{T_s} \ln \left(\sum_{i=1}^{M_s} A_{si}^{T_s} \right) \\ &- \frac{1}{2} \gamma T_s \left[\begin{array}{l} \phi_s \text{var}(\ln MRPK_{si}) + \varphi_s \text{var}(\ln MRPL_{si}) \\ +2\gamma \alpha_s \beta_s \text{cov}(\ln MRPK_{si}, \ln MRPL_{si}) \end{array} \right] \end{aligned} \tag{7}$$

where $\phi_s = \alpha_s \left[1 - \beta_s \left(\frac{\sigma-1}{\sigma}\right)\right]$, $\varphi_s = \beta_s \left[1 - \alpha_s \left(\frac{\sigma-1}{\sigma}\right)\right]$, $\gamma = \frac{\sigma}{\sigma-1}$. We assume that firm profits are positive in the absence of distortions. Thus, $\phi_s > 0$, $\varphi_s > 0$, $T_s > 0$.

[1] Hsieh and Klenow (2009) express the distortions in terms of output and capital relative to labor. They show in Appendix III that these are equivalent to a combination of capital ($\tau_{K_{si}}$) and labor ($\tau_{L_{si}}$) distortions as what we do.

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