Measuring and Explaining Resource Misallocation Across Industries and its Impact on China's Aggregate TFP Growth

Harry X Wu (Hitotsubashi University, Japan) and Zhongwen Zhang (Peking University, China)

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MEASURING AND EXPLAINING RESOURCE MISALLOCATION ACROSS INDUSTRIES AND ITS IMPACT ON CHINA'S AGGREGATE TFP GROWTH

Harry X. Wu
Institute of Economic Research, Hitotsubashi University
harry.wu@ier.hit-u.ac.jp

Zhongwen Zhang
School of Economics, Peking University
zhangzhongwen@pku.edu.cn

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ABSTRACT

We propose an approach to better address the resource misallocation problem that is observed particularly in emerging economies such as China and India due to institutional deficiencies (e.g. Hsieh and Klenow, 2009). By incorporating the Domar aggregation scheme, Jorgenson's aggregate production possibility frontier framework is able to quantify a net factor reallocation effect across industries on the aggregate TFP growth (Jorgenson *et al*., 2005). However, it is unable to identify the industry origin of resource misallocation that essentially drives the economy-wide reallocation process. By adopting an Aoki-type decomposing approach (Aoki, 2012), yet fully taking into account intermediate inputs as in Jorgenson *et al*. (2005), this approach is able to measure the degree of industry-specific factor misallocation by relative distortion coefficient (RDC) and then account for the change of RDC for all industries as an aggregate factor reallocation effect (RE), which is conceptually made up to the RE of Jorgensonian model, and further to estimate industry-specific RE by factor using a counterfactual approach. We have preliminarily applied this approach to the new version of the China Industry Productivity (CIP) data. Besides, we also empirically test our institutional argument for resource misallocation by estimating a set of RE models with explanatory variables to capture the role of state.

Keywords: total factor productivity; resource misallocation; resource reallocation; relative distortion; institutional factors

***JEL* Classification**: O47, E10, E24, C82

1. INTRODUCTION

Recent empirical studies have paid serious attention to resource misallocation and potential gains from efficient resources reallocation in emerging economies such as China and India (Hsieh and Klenow 2009; Dollar and Wei 2007). In fact, even in the heyday of China's super fast growth, while many economists appraise competitions between local governments for high growth (see Xu 2011 for a comprehensive review), Wu Jinglian (J. Wu 2005) warned that the government-engineered, extensively investment-driven growth model could not be sustainable because of increasingly wasteful use of resources.

Although efforts have been made to empirically estimate the effect of resource misallocation on output and productivity (e.g. Hsieh and Klenow 2009) and to gauge underpaid factor costs in China due to market distortions (e.g. Huang and Tao 2010; Geng and N'Diaye 2012), most studies rely on partial, sub-national or limited survey data, which cannot fully capture the effect of the observed misallocation problem on the rest of the unobserved economy. Therefore, an industry-based, economy-wide systematic approach is in order to address the misallocation problem.

Syrquin (1986) empirically manifests that resource reallocation has a significant effect on the aggregate productivity growth. Using an aggregate production possibility frontier (APPF) framework incorporating Domar weights, Jorgenson et al. (2005) decompose reallocation effect into two sources, capital and labor, as one source of TFP growth in the US economy. This reallocation effect quantifies the departure from the assumption of equal factor costs, which illustrate the concept of resource misallocation. However, the Jorgensonian model is unable to identify the industry origin of resource misallocation that essentially drives the economy-wide reallocation process.

This paper proposes a gross output accounting framework that allows an analysis of the varied degree of resource misallocation across industries and an exploration of the industry origin of the aggregate reallocation effect. This framework is based on Jorgenson's APPF framework (Jorgenson, Ho and Stiroh 2005). By introducing industry-specific frictions in the form of taxes on primary factor inputs as in Aoki (2012), Restuccia and Rogerson (2008) and Hsieh and Klenow (2009), we address policies that create idiosyncratic distortions to representative firms' decisions at industry level and hence cause a reallocation of resources across industries. These industry-specific frictions are measured by relative returns on factors across industries. Further, following an Aoki-type approach, we decompose the aggregate reallocation effect into contributions of each industry. By incorporating the Domar aggregation scheme in Jorgenson et al. (2005), our approach could capture the multiplier effect of intermediate inputs by gross output approach rather than value added approach as major studies on misallocation (e.g. Hsieh and Klenow 2009; Aoki 2012).

This study is benefited by the newly available China Industry Productivity (CIP) data set for 1980-2010, preliminarily updated to 2012, constructed by Wu and his associates (Wu 2008, 2015a; Wu and Ito 2015; Wu and Yue 2012; Wu, Yue and Zhang 2015), which has for the first time satisfied the homogeneity requirement in measuring factor inputs and the cost or income coherence requirement between the national accounts and the industry accounts of the whole Chinese economy.

We apply the framework presented here to the CIP data set and find that resource reallocation effect (RE) accounts for 0.29% to the aggregate TFP growth 0.94% on annual average from 1980-2012, and RE for labor contributes for 0.52% on annual average while RE for capital contributes for -0.22% on annual average. Using an Aoki-type of counterfactual analysis, the industry origin of the aggregate reallocation effect is explored and estimated (Aoki, 2012).

We further empirically test the institutional hypothesis for resource misallocation. Despite a series of reforms over the past three decades, there are still many institutional barriers to constrict the mobility of resources for china's economy. Plenty of research (Dollar and Wei 2007; Hsieh and Klenow 2009) shows ownership is one key factor. Export-oriented policy is also a characteristic of china's economy during the past 3 decades. Government intervention is also an important factor which is widely illustrated (Huang 2012; Wu et al. 2015b; Wu 2015b; Xu 2011), governments have strong incentive to choose idiosyncratic intervenes or subsidies to different industries taking consider with the GDP performance and tax volume.

We thus investigate the influence of some important institutional factors to the reallocation effect of resources. In a regression exercise, we include SOE ratio of employment, export ratio of gross output and production tax ratio of value added to capture the effects of ownership, export-oriented policy and government intervention. We find the results basically support our conjecture about the role of state. We also find positive reform shocks, such as China's WTO accession.

The remainder of the paper is organized into six sections. Section 2 reviews some related literatures. Section 3 sets up a gross output accounting framework that measures the effect of resource misallocation across sectors on aggregate TFP .Section 4 describes the data sets. Section 5 measures the effect of sector-level resource misallocation on aggregate TFP growth from data. Section 6 analyzes effect of some institutional variables to resource reallocation effect by panel regression. Section 7 contains the concluding remarks.

2. LITERATURE REVIEW

There are several papers that calculate resource misallocation effect on aggregate TFP using micro-level data or industry-level data. Using a standard model of monopolistic competition with heterogeneous firms and manufacturing plant-level data from China, India and the US, Hsieh and Klenow (2009) estimated that manufacturing TFP gains of 30%–50% in China and 40%–60% in India when capital and labor were hypothetically reallocated to equalize marginal products to the extent observed in the United States. The closest to our model, Aoki (2012) developed a simple accounting framework and adopted industry-level data from EU-KLEMS database to fit his framework, then he found that the effect of resource misallocation is quantitatively large and explains more than 9% of the differences in the aggregate productivity between Japan and the US. Comparing with these works, this paper has some innovations. First, we adopt gross output industrial production function rather than value added function, which can capture the multiplier effect of intermediate inputs (Jones 2011a and 2011b). Also, we use the newly available China Industry Productivity (CIP) data set for 1980-2012. On one hand, it guarantees the homogeneity of the inputs across sectors. On the other hand, it makes our paper the first try to analyze resource misallocation of china's economy systematically and comprehensively owing to including the whole economy rather than some part of industries (Hsieh and Klenow 2009; Brandt, Tombe and Zhu 2013). What is more, this paper is the first try that combing decomposition of reallocation effect from aggregate TFP at macro-level and explanation of reallocation effect by institutional variables at micro-level.

A very important branch of the economics literature studied the impact of intermediate goods. Leontief (1936) initially raised the notion that linkages across sectors can be central to economic performance during the work of input-output economics. Hulten (1978) insisted that the intermediate inputs served to magnify the effect of technical change across sectors, thus had the vital impact on the aggregate productivity. Jorgenson et al. (2005) adopted "Domar weight" to illustrate the industry TFP has two effects on aggregate TFP: the direct effect on industry output, and a indirect effect via intermediate flows. However, the literature related to the resource misallocation typically ignored intermediate goods (Jones 2011a and 2011b). This paper introduces the intermediate inputs into analysis of resource misallocation through gross output industrial production function, which is a supplement to the research on this field.

There are several papers that measure labor income share in china from 2005. The long-term stability of factor shares has become enshrined as one of the "stylized facts" of growth (e.g., Kaldor 1961), Gollin (2012) further verified the facts by Several adjustments, such as considering self-employment Income. However, as the rapid developing country, the facts of china can't be described by properties under the steady state. Bai and Qian (2009) investigated the change in aggregate labor income share in China since 1995, they found the measured labor income share declined by 5.48 percentage points during 1995-2003 after considering effect of the first economic census. Wu (2014) reconstructed the IOTs time series based the KLEMS framework and realized that the labor income share was time-variant, declining from about 0.59 in 1952 to 0.45 in 1978 and further to 0.41 in 2007. This paper uses the time-variant income share of inputs to fit the real situation of Chinese economy.

The comparable growth and productivity analysis asks for the homogenous volume of factor inputs. If the input data are heterogeneous, the production function cannot be homothetically separable (Jorgenson 1990). The essential idea of constructing factor input index roots in the heterogeneity of different type of factors. With the limitation of high quality data, many previous works related resource misallocation or productivity in China did not take the heterogeneity into consideration. Most studies have simply used the numbers employed implicitly as a proxy for labor input, irrespective of improperness and inconsistencies in various aspects (e.g. Borensztein and Ostry 1996; Chen et al. 1988; Chow 1993; Hu and Khan 1997; Bosworth and Collins 2008; Perkins and Rawski 2008). Many studies have used estimated capital stock as a proxy for capital input, without considering the efficiency of current investment (Young 2003). This paper highlights the homogeneity of primary inputs on both conceptual level and empirical level.

3. Model for Measuring Factor Misallocation

Industry gross output function

There are N industrial sectors in the economy. As APPF framework by Jorgenson, firms in each sector produce goods (homogeneous within a sector but heterogeneous between sectors) by using three factor inputs: capital input K ,labor input L and intermediate input X. Firms are price-takers in both the good and factor markets, and pay linear taxes on capital and labor inputs (owing to explore the magnified effect of intermediate inputs rather than misallocation of intermediate inputs itself, thus no taxes on intermediate inputs), which vary by sectors since we take the misallocation across industries into consideration. Thus, firms in sector i produce goods given the goods price of the sector, p_{Yi} and capital and labor costs, $(1+\tau_{Ki})\ p_K$ and $(1+\tau_{Li})\ p_L$, where p_K and p_L are the common factor prices of capital and labor across sectors, and τ_{Ki} and τ_{Li} are capital and labor taxes of the sector. As mentioned in the introduction, many different types of policies (e.g. Barrier to labor mobility, Imperfect competition, Borrowing constraint) may generate idiosyncratic distortions to representative firms at industry level, However, it is difficult or impossible to measure directly the sources of misallocation in some cases. The approach we take here is to analyze a generic family of distortions of this type. We assume that τ can take on three values: a positive value reflecting that the industry is being taxed, a negative value reflecting that the industry is being subsidized, and zero reflecting no distortion for the industry. The price of intermediate inputs p_{Xi} varies across sectors, since constitute of intermediate inputs is different between industries.

The firms have Cobb-Douglas production technology exhibiting constant returns to scale[1]. Therefore, a firm i's gross output production function can be written as follows:

(1) $$Y_i = F_i(A_i, K_i, L_i, X_i) = A_i K_i^{\alpha_i} L_i^{\beta_i} X_i^{1-\alpha_i-\beta_i}$$

Y_i is gross output, K_i is capital input, L_i is labor input, X_i is intermediate input and A_i is TFP[2]. We assume that the capital and labor output elasticity α_i and β_i can vary by sector.

In this setting, the firm's problem is written as:

(2) $$\max_{K_i, L_i, X_i}\{p_{Yi}Y_i - (1+\tau_{Ki})p_K K_i - (1+\tau_{Li})p_L L_i - p_{Xi}X_i\}$$

The *FOC*s are as follows:

(3) $$\frac{\alpha_i p_{Yi} Y_i}{K_i} = (1+\tau_{Ki})p_K$$

(4) $$\frac{\beta_i p_{Yi} Y_i}{L_i} = (1+\tau_{Li})\ p_L$$

(5) $$\frac{(1-\alpha_i-\beta_i)p_{Yi} Y_i}{X_i} = p_{Xi}$$

1 Actually we don't need to use specific function form for industry production function, only constant return to scale assumption is necessary just like in APPF. Using Cobb-Douglas production form is convenient for readers to understand the process.
2 These inputs used in industry production function are aggregate input indexes, which is attained by Tornqvist index of different types of lower-level inputs. The detailed process of constructing inputs is expressed in section 4.

Aggregation function

When we consider the performance of the aggregate economy, it is reasonable to estimate the value added of the whole economy (GDP). We assume the aggregate value added V (the price scaled to unit) can be expressed by an aggregate function of industrial value added V_i :

(6) $$V = F(V_1, \cdots, V_N)$$

Where $F(\cdot)$ is assumed to constant returns to scale(CRS) ，and We also assume that the following condition is satisfied:

(7) $$\frac{\partial V}{\partial V_i} = p_{Vi}$$

Where p_{Vi} is the price of the value-added of industry i . Under this condition, the following equation holds:

(8) $$\mathrm{V} = \sum_{i=1}^{N} p_{Vi} V_i$$

Equation (8) has the implication that the sum of nominal value added of all industries equals the nominal value added of the whole economy(or nominal GDP), which is absolutely satisfied.

We define the industry value-added function as APPF, which gives the quantity of value-added as a function of only capital input, labor input and TFP as:

(9) $$V_i = g_i(A_i, K_i, L_i)$$

Industrial value-added and gross output relationship can be re-written as：

(10) $$Y_i = f_i(V_i, X_i) = f_i(g_i(A_i, K_i, L_i)\ , X_i)$$

Under the assumption of constant returns to scale and competitive markets, the value of output is equal to the value of all inputs:

(11) $$p_{Yi} Y_i = (1 + \tau_{Ki}) p_K K_i + (1 + \tau_{Li}) p_L L_i + p_{Xi} X_i$$

Value-added consist of capital and labor inputs, and the nominal value is simply:

(12) $$p_{Vi} V_i = p_{Yi} Y_i - p_{Xi} X_i = (1 + \tau_{Ki}) p_K K_i + (1 + \tau_{Li}) p_L L_i$$

According to APPF，the quantity of value-added V_i is defined implicitly from a Tornqvist expression for gross output：

(13) $$\ln\left(\frac{Y_i^{t+1}}{Y_i^t}\right) = \bar{v}_{Vi} \ln\left(\frac{V_i^{t+1}}{V_i^t}\right) + \bar{v}_{Xi} \ln\left(\frac{X_i^{t+1}}{X_i^t}\right)$$

Where $\bar{v}_{Vi}$ and $\bar{v}_{Xi}$ are the two-period average nominal share of value-added and intermediate input in industry gross output：

$$v_{Vi} = \frac{(1+\tau_{Ki}) p_K K_i + (1+\tau_{Li}) p_L L_i}{p_{Yi} Y_i}\ , \qquad \bar{v}_{Vi} = 1/2\left(v_{Vi}^{t+1} + v_{Vi}^{t}\right)$$

$$v_{Xi} = \frac{p_{Xi} X_i}{p_{Yi} Y_i} \ , \qquad \bar{v}_{Xi} = 1/2\left(v_{Xi}^{t+1} + v_{Xi}^{t}\right)$$

The price of value-added p_{Vi} is defined implicitly to make the identity（12）hold.

Resource constraint

Finally, we assume that aggregate capital and labor supply are exogenous. Thus, the following resource constraints apply[3]：

(14) $$\sum_{i=1}^{N} K_i = K$$

(15) $$\sum_{i=1}^{N} L_i = L$$

Distortion coefficients

According to (3), (4), (14) and (15), we derive the expressions for K_i and L_i

(16) $$K_i = \frac{\frac{(1+\tau_{Ki}) p_K K_i}{(1+\tau_{Ki}) p_K}}{\sum_j \frac{(1+\tau_{Kj}) p_K K_j}{(1+\tau_{Kj}) p_K}} K$$

$$= \frac{\frac{\alpha_i p_{Yi} Y_i}{(1+\tau_{Ki}) p_K}}{\sum_j \frac{\alpha_j p_{Yi} Y_j}{(1+\tau_{Kj}) p_K}} K$$

$$= \frac{\frac{\tilde{\sigma}_i \alpha_i}{1+\tau_{Ki}}}{\sum_j \frac{\tilde{\sigma}_j \alpha_j}{1+\tau_{Kj}}} K$$

(17) $$L_i = \frac{\frac{\tilde{\sigma}_i \beta_i}{1+\tau_{Li}}}{\sum_j \frac{\tilde{\sigma}_i \beta_i}{1+\tau_{Lj}}} L$$

Where $\tilde{\sigma}_i$ is the ratio of industrial gross output to aggregate value-added $\frac{p_{Yi} Y_i}{V}$, which is the usual interpretation of the Domar-weight (Domar, 1961). A distinctive feature of Domar-weight is that they typically sum to more than one.

In order to further analysis，we define two types of distortion coefficients.

Definition 1: Absolute distortion coefficients of capital and labor input for industry i , $\lambda_{Ki} = \frac{1}{1+\tau_{Ki}}$, $\lambda_{Lj} = \frac{1}{1+\tau_{Li}}$, where τ_{Ki} and τ_{Li} are capital and labor taxes of the sector.

Definition 2: Relative distortion coefficients of capital and labor input for industry i , $\tilde{\lambda}_{Ki} = \frac{\lambda_{Ki}}{\sum_j \left(\frac{\tilde{\sigma}_j \alpha_j}{\tilde{\alpha}}\right) \lambda_{Kj}}$, $\tilde{\lambda}_{Li} = \frac{\lambda_{Li}}{\sum_j \left(\frac{\tilde{\sigma}_j \beta_j}{\tilde{\beta}}\right) \lambda_{Kj}}$, where $\tilde{\alpha} = \sum_i \tilde{\sigma}_i \alpha_i$, $\tilde{\beta} = \sum_i \tilde{\sigma}_i \beta_i$ are

[3] We need to establish equations for each type of primary inputs (e.g. structure and equipment) in order to satisfy strictly the homogenous input requirement as APPF, however, it is meaningless and almost impossible to depict the misallocation for each type of primary inputs, thus we use this simplification.

separately expressed as Domar-weighted average of production elasticity for capital and labor.

Absolute distortion coefficients reflect the distortion degree of factors' cost contrast to the no distortion state and depict the absolute cost of factors. For example, if capital input for industry *i* faces no distortion, thus $\tau_{Ki} = 0$, then $\lambda_{Ki} = 1$; if the price of capital input is higher than that of no distortion, thus $\tau_{Ki} > 0$, then $0 < \lambda_{Ki} < 1$; if the price of capital input is lower than that of no distortion, thus $\tau_{Ki} < 0$, then $\lambda_{Ki} > 1$.

Relative distortion coefficients reflect the distortion degree of factors' cost contrast to the average distortion degree of factors' cost for the whole economy, which is the signal deciding the resource allocation. For example, if λ_{Ki} is smaller than the weighted average of λ_{Kj} (i.e., sector *i*'s capital is taxed more), then $\tilde{\lambda}_{Ki}$ becomes less than unity and less capital is allocated to sector i than to the level with no frictions.

In the empirical section, we do not measure absolute distortion coefficients, but measure relative distortion coefficients, which capture the distribution of frictions.

Combining definition 2,（16）and （17），thus:

(18) $$K_i = \frac{\tilde{\sigma}_i \alpha_i}{\tilde{\alpha}} \tilde{\lambda}_{Ki} K$$

(19) $$L_i = \frac{\tilde{\sigma}_i \beta_i}{\tilde{\beta}} \tilde{\lambda}_{Li} L$$

So the relative distortion coefficients are measured using the following equations：

(20) $$\tilde{\lambda}_{Ki} = \left(\frac{\tilde{\sigma}_i \alpha_i}{\tilde{\alpha}}\right)^{-1} \frac{K_i}{K} , \quad \tilde{\lambda}_{Li} = \left(\frac{\tilde{\sigma}_i \beta_i}{\tilde{\beta}}\right)^{-1} \frac{L_i}{L}$$

For capital, $\frac{K_i}{K}$ is the actual capital ratio of industry *i* accounts for the whole economy, while $\frac{\tilde{\sigma}_i \alpha_i}{\tilde{\alpha}}$ measures the theoretical capital ratio of industry *i* should be allocated if the resources are allocated efficiently. So the rate of the two ratios $\tilde{\lambda}_{Ki}$ can be measured as the degree of resource misallocation for capital inputs in industry *i*. If the rate bigger than one, it means industry *i* overused capital inputs; otherwise, it means industry *i* underused capital inputs. As defined in above, $\tilde{\lambda}_{Ki}$ is the relative distortion coefficient of capital input for industry *i*. If $\tilde{\lambda}_{Ki} > 1$, which means the relative cost of capital input in this industry is low, this industry has the incentive to overuse the capital input; If $\tilde{\lambda}_{Ki} < 1$, which means the relative cost of capital input in this industry is high, this industry has the incentive to underuse the capital input. Through the equations (20), the linkage between distortion of the factor's price and factors misallocation has been constructed.

Decomposition of aggregate TFP

In order to analyze the effect of resource misallocation on aggregate TFP, we compare the aggregator function between two adjacent periods.

By applying the mean value theorem and using (7) and (8), thus

$$\ln\frac{V_{t+1}}{V_t}=\sum_i\frac{\partial lnV}{\partial lnV_i}\ln\left(\frac{V_i^{t+1}}{V_i^t}\right)\approx\sum_i\bar{\omega}_i\ln\left(\frac{V_i^{t+1}}{V_i^t}\right) \tag{21}$$

where $\bar{\omega}_i$ is the average share of industry value-added in aggregate value-added：

$$\omega_i=\frac{p_{Vi}V_i}{V}\ ,\qquad \bar{\omega}_i=1/2\left(\omega_i^{t+1}+\omega_i^t\right)$$

Equation (21) is consistent with the relationship between aggregate value-added and industry value-added in APPF. According to APPF, the TFP growth rate of industry *i* can be decomposed as:

$$\ln\left(\frac{A_i^{t+1}}{A_i^t}\right)=\ln\left(\frac{Y_i^{t+1}}{Y_i^t}\right)-\bar{v}_{Xi}\ln\left(\frac{X_i^{t+1}}{X_i^t}\right)-\bar{v}_{Ki}\ln\left(\frac{K_i^{t+1}}{K_i^t}\right)-\bar{v}_{Li}\ln\left(\frac{L_i^{t+1}}{L_i^t}\right) \tag{22}$$

Considering the relationship between value-added and gross output, according to (13), thus

$$\ln\left(\frac{V_i^{t+1}}{V_i^t}\right)=\frac{\bar{v}_{Ki}}{\bar{v}_{Vi}}\ln\left(\frac{K_i^{t+1}}{K_i^t}\right)+\frac{\bar{v}_{Li}}{\bar{v}_{Vi}}\ln\left(\frac{L_i^{t+1}}{L_i^t}\right)+\frac{1}{\bar{v}_{Vi}}\ln\left(\frac{A_i^{t+1}}{A_i^t}\right) \tag{23}$$

Plunging (18), (19) and (23) into (21), we attain

$$\begin{aligned}\sum_i\bar{\omega}_i\ln\left(\frac{V_i^{t+1}}{V_i^t}\right)&=\sum_i\bar{\omega}_i\left\{\frac{\bar{v}_{Ki}}{\bar{v}_{Vi}}\ln\left(\frac{K_i^{t+1}}{K_i^t}\right)+\frac{\bar{v}_{Li}}{\bar{v}_{Vi}}\ln\left(\frac{L_i^{t+1}}{L_i^t}\right)+\frac{1}{\bar{v}_{Vi}}\ln\left(\frac{A_i^{t+1}}{A_i^t}\right)\right\}\\&=\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\left\{\ln\left(\frac{A_i^{t+1}}{A_i^t}\right)+\bar{\alpha}_i\ln\left(\frac{K_i^{t+1}}{K_i^t}\right)+\bar{\beta}_i\ln\left(\frac{L_i^{t+1}}{L_i^t}\right)\right\}\\&\approx\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\left\{\ln\left(\frac{A_i^{t+1}}{A_i^t}\right)+\bar{\alpha}_i\ln\left(\frac{\tilde{\lambda}_{Ki}^{t+1}}{\tilde{\lambda}_{Ki}^t}\right)+\bar{\beta}_i\ln\left(\frac{\tilde{\lambda}_{Li}^{t+1}}{\tilde{\lambda}_{Li}^t}\right)\right\}\\&\quad+\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\bar{\alpha}_i\ln\left(\frac{K^{t+1}}{K^t}\right)+\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\bar{\beta}_i\ln\left(\frac{L^{t+1}}{L^t}\right)\end{aligned} \tag{24}$$

Where $\bar{v}_{Ki}$ and $\bar{v}_{Li}$ are average share of capital and labor input in nominal gross output of industry：

$$v_{Ki}=\frac{(1+\tau_{Ki})p_KK_i}{p_{Yi}Y_i}=\alpha_i\ ,\qquad \bar{v}_{Ki}=1/2\left(v_{Ki}^{t+1}+v_{Ki}^t\right)=\bar{\alpha}_i$$

$$v_{Li}=\frac{(1+\tau_{Li})p_LL_i}{p_{Yi}Y_i}=\beta_i\ ,\qquad \bar{v}_{Li}=1/2\left(v_{Li}^{t+1}+v_{Li}^t\right)=\bar{\beta}_i$$

According to APPF, we define ATFP as the growth rate of aggregate TFP, thus

$$\text{ATFP}=\sum_i\bar{\omega}_i\ln\left(\frac{V_i^{t+1}}{V_i^t}\right)-\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\bar{\alpha}_i\ln\left(\frac{K^{t+1}}{K^t}\right)-\sum_i\frac{\bar{\omega}_i}{\bar{v}_{Vi}}\bar{\beta}_i\ln\left(\frac{L^{t+1}}{L^t}\right)$$

Rewriting (24), thus

$$\text{ATFP} \approx \sum_i \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \ln\left(\frac{A_i^{t+1}}{A_i^t}\right) + \sum_i \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \left\{ \bar{\alpha}_i \ln\left(\frac{\tilde{\lambda}_{Ki}^{t+1}}{\tilde{\lambda}_{Ki}^t}\right) + \bar{\beta}_i \ln\left(\frac{\tilde{\lambda}_{Li}^{t+1}}{\tilde{\lambda}_{Li}^t}\right) \right\} \tag{25}$$

We refer to the first term of the RHS in (25) as sectoral TFP term (*STFP*). *STFP* is a weighted average of the growth rate of sectoral TFPs with Domar-weight. The distinctive feature of Domar-weight is that they sum to more than one, which reflects that an improvement in industry TFP can have two effects: a direct effect on industry output, and an indirect effect via intermediate flows (Jorgenson et al., 2005). In other words, the intermediate inputs can magnify the effect of industry TFP growth to the aggregate TFP growth, the multiplier is positive proportional with $\frac{p_{Xi} X_i}{p_{Vi} V_i}$. The second term of the RHS in (25) consists of frictions. We refer to it as reallocation effect term (*RE*). *RE* measures the effect of change of distortions on resource allocation on aggregate TFP growth. If $E > 0$, it illustrates that the resource allocation becomes better; if $RE < 0$, it illustrates that the resource allocation becomes worse. The intermediate inputs have no effect on the *RE* term, since the intermediate input part will cancel out from *RE* term after calculation. Because introduction of intermediate inputs can magnify the contribution of sectoral TFP growth and have no effect on the reallocation effect term, it will decrease the contribution of reallocation effect term to the aggregate TFP growth. In order to analyze the contribution of primary factors to reallocation effect, *RE* can be divided into two parts: *RE(K)* and *RE(L)*, where $RE(K) = \sum_i \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \bar{\alpha}_i \, ln\left(\frac{\tilde{\lambda}_{Ki}^{t+1}}{\tilde{\lambda}_{Ki}^t}\right)$, $RE(L) = \sum_i \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \bar{\beta}_i \, ln\left(\frac{\tilde{\lambda}_{Li}^{t+1}}{\tilde{\lambda}_{Li}^t}\right)$.

Output loss between real output and potential output

In order to investigate the effect of resource misallocation to aggregate TFP, we estimate the output loss between two states: the one is the real output under condition that there is resource misallocation , the other is the potential output under condition that inputs are allocated efficiently.

According to previous part, we just need to replace $V_{\mathrm{t+1}}$ with the real output of economy V_t^r , and replace V_{t} with the potential output of economy V_t^e . We assume that share of each industry value-added in aggregate value-added and output elasticity of inputs are constant at two states. Also we assume the sectoral TFP levels are kept constant at two states. Aggregate capital and labor supply are still assumed as exogenous. Thus, the output loss(the TFP loss) can be expressed as

$$\ln\left(\frac{V_t^r}{V_t^e}\right) = \sum_i \frac{\omega_i^t}{v_{Vi}^t} \left\{ \alpha_i \ln\left(\frac{\tilde{\lambda}_{Ki}^t}{\tilde{\lambda}_{Ki}^e}\right) + \beta_i \ln\left(\frac{\tilde{\lambda}_{Li}^t}{\tilde{\lambda}_{Li}^e}\right) \right\} \tag{26}$$

Where $\tilde{\lambda}_{Ki}^e$ and $\tilde{\lambda}_{Li}^e$ are relative distortion coefficients of capital and labor input for industry *i* under condition that inputs are allocated efficiently. As we know, the equal price of inputs across sectors is satisfied, thus, $\tilde{\lambda}_{Ki}^e = \tilde{\lambda}_{Li}^e = 1$. Then we rewrite (26) into:

(27) $$\ln\left(\frac{V_t^r}{V_t^e}\right) = \sum_i \frac{\omega_i^t}{v_{Vi}^t}\left\{\alpha_i \ln\left(\tilde{\lambda}_{Ki}^t\right) + \beta_i \ln\left(\tilde{\lambda}_{Li}^t\right)\right\}$$

According to (27), output loss depends on share of each industry value-added in aggregate value-added, capital and labor share of each industry in value added, and relative distortion coefficients of capital and labor input for each industry.

Contribution of each sector to RE

In order to identify the contribution of sector i RE_i, we adopt the method in Aoki(2012). We fix factor inputs of a particular sector (we refer to it as sector *i*) to its actual observed values and then reallocated efficiently the remaining factor inputs across the remaining sectors of the economy. Then, the only source of distortion would be in sector *i*. For simplicity, we also assume that sectoral domar-weight and output elasticity are fixed. We refer to the *RE* calculated under this assumption as RE_i .

First, according to (18), $\tilde{\lambda}_{Ki}$ is the same as the actual one. Second, since factor prices are the same across the remaining sectors, $\tilde{\lambda}_{Km} = \tilde{\lambda}_{Kn} = \tilde{\lambda}_{K-i}$ for the remaining sectors (m and n are sectors that are not sector i and we summarize these sectors by $-i$).

In the empirical section, $\tilde{\lambda}_{K-i}$ used in RE_{Ki} is measured in the following way. By rearranging,

(28) $$K_{-i} = K - K_i = \sum_{m\neq i} K_m = \sum_{m\neq i} \frac{\tilde{\sigma}_m \alpha_m}{\tilde{\alpha}} \tilde{\lambda}_{K-i} K$$

We obtain

(29) $$\tilde{\lambda}_{K-i} = \left(\frac{\tilde{\sigma}_{-i}\alpha_{-i}}{\tilde{\alpha}}\right)^{-1} \frac{K_{-i}}{K}$$

Where $\tilde{\sigma}_{-i} = \frac{\sum_i p_{Yi} Y_i}{V} - \tilde{\sigma}_i$ and $\alpha_{-i} = \sum_{m\neq i} \frac{\tilde{\sigma}_m}{\tilde{\sigma}_{-i}} \alpha_m$ (i.e., α_{-i} is a weighted average of α_m（$m \neq i$）).

Thus we get the contribution of industry *i* RE_{Ki} when there is only distortion of capital input in this industry.

(30) $$\mathrm{RE}_{Ki} = \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \bar{\alpha}_i \ln\left(\frac{\tilde{\lambda}_{Ki}^{t+1}}{\tilde{\lambda}_{Ki}^t}\right) + \sum_{m\neq i} \frac{\bar{\omega}_m}{\bar{v}_{Vm}} \bar{\alpha}_m \ln\left(\frac{\tilde{\lambda}_{K-i}^{t+1}}{\tilde{\lambda}_{K-i}^t}\right)$$

In the same way, we get the contribution of industry *i* RE_{Li} when there is only distortion of labor input in this industry.

(31) $$\mathrm{RE}_{Li} = \frac{\bar{\omega}_i}{\bar{v}_{Vi}} \bar{\beta}_i \ln\left(\frac{\tilde{\lambda}_{Li}^{t+1}}{\tilde{\lambda}_{Li}^t}\right) + \sum_{m\neq i} \frac{\bar{\omega}_m}{\bar{v}_{Vm}} \bar{\beta}_m \ln\left(\frac{\tilde{\lambda}_{L-i}^{t+1}}{\tilde{\lambda}_{L-i}^t}\right)$$

where

(32) $$\tilde{\lambda}_{L-i} = \left(\frac{\tilde{\sigma}_{-i}\beta_{-i}}{\tilde{\beta}}\right)^{-1}\frac{L_{-i}}{L}$$

$$\beta_{-i} = \sum_{m \neq i}\frac{\tilde{\sigma}_m}{\frac{p_{Yi}Y_i}{V} - \tilde{\sigma}_i}\beta_m \qquad L_{-i} = L - L_i$$

4. DATA

This study has uniquely benefited from a newly constructed economy-wide, industry-level data set in the on-going CIP Project. It is beyond the scope of this study to go through a long history of separate database studies.[4] We refer the interested reader for details to three working papers (Wu 2015; Wu and Ito 2015; Wu, Yue and Zhang 2015) as well as earlier versions of this work if one wants to trace the development of the data construction ideas (e.g. Wu 2008 and 2012; Wu and Xu 2002; Wu and Yue 2003, 2010 and 2012).

In the CIP Project the principles of industry data construction adhere to the underlying theory as expressed in detail in accounting of U.S. economic growth in Jorgenson et al. (2005). For the classification of industries, we in principle adopt the 2002 version of the Chinese Standard Industrial Classification (CSIC/2002) and reclassify the economy into 37 industries (see Appendix Table A1). Each sector of the economy is described by a production function, which uses primary factors and intermediate inputs to produce gross output. This output is used for final demand and intermediate demand, and GDP is the aggregate of final demand. Nominal GDP is also the sum of sectoral value added, which implies that the industry-level data are linked to and made consistent with the national production and income accounts of China.

Output and intermediate input

We must have the IOTs in time series to get time series data of output and intermediate input. Unfortunately there are only five full-scale IOTs, so we have to reconstruct the IOTs in time series based on the five benchmarks (Wu and Ito 2015). Based on the constructed IOTs in time series, on one hand, we can get the output for sectors directly, on the other hand, we have to use the Tornqvist aggregate to get the intermediate input for sectors.

(33) $$\ln\left(\frac{X_i^{t+1}}{X_i^t}\right) = \sum_j v_{ij}^X \ln\left(\frac{X_{ij}^{t+1}}{X_{ij}^t}\right)$$

Where X_i is the intermediate input for industry *i*, X_{ij} is the intermediate input of type *j* for industry *i*, v_{ij}^X is the average share of X_{ij} in nominal intermediate input for industry *i*, $v_{ij}^X = {}^1\!/_2\left(v_{ij\,(t+1)}^X + v_{ijt}^X\right)$, $v_{ijt}^X = \frac{p_{jt}^X X_{ij}^t}{\sum_j p_{jt}^X X_{ij}^t}$.

[4] The CIP project is based on Wu's China Growth and Productivity Database project, self-initiated in 1995 and heavily involved in Angus Maddison's work on China's aggregate economic performance from 1912 and manufacturing, mining and utility industries from 1949 (see Maddison 1998 and 2007; Maddison and Wu 2008). The CIP project began in 2010 aiming to extend Wu's earlier work to all non-industrial sectors under the KLEMS framework.

Capital input

The method involves distinguishing between the stock of capital and the flow of services derived from them and is described in detail in Jorgenson et al. (2005, chapter 5). Wu（2015a）introduced the detailed process of constructing the capital service series in China.

The stock of capital of type *k* in sector *i* $A_{k,i,t}$ is accumulated from the flow of investment using the perpetual inventory method. Owing to the new investment can't be used efficiently into production, the capital input $K_{k,i,t}$ is different from the capital stock $A_{k,i,t}$. The difference between capital stock and capital service can be expressed as

(34) $$K_{k,i,t} = Q_{K,k,i} \frac{1}{2}\left(A_{k,i,t} + A_{k,i,t-1}\right) = Q_{K,k,i} \cdot Z_{k,i,t}$$

Where $Z_{k,i,t}$ is two-period average capital stock, $Q_{K,k,i}$ is the proportionality factor.

Jorgenson (1963) raised the rental price of capital service (without considering tax) as:

(35) $$P_{K,k,i,t} = \left(i_{i,t} - \pi_{k,i,t}\right)P_{I,k,i,t-1} + \delta_k P_{I,k,i,t}$$

where $P_{I,k,i,t}$ is acquisition price of capital, $i_{i,t}$ is the nominal interest, δ_k is the rate of economic depreciation, $\pi_{k,i,t}$ is the asset-specific capital gains.

With the capital input flow $K_{k,i,t}$ and capital input price $P_{K,k,i,t}$ for each asset, industry and time period. To generate estimates for total capital service flows within an industry, we use a Tornqvist quantity index to aggregate over assets as below

(36) $$\Delta\ln K_{i,t} = \sum_k \bar{v}_{k,i,t}\, \Delta\ln Z_{k,i,t}$$

(37) $$v_{k,i} = \frac{P_{K,k,i}K_{k,i}}{\sum_k P_{K,k,i}K_{k,i}}$$

Where $\Delta\ln K_{i,t} = \ln\left(\frac{K_{i,t}}{K_{i,t-1}}\right)$, $v_{k,i}$ is the share of *k th* capital input used in industry *i* in the value of capital input for this industry.

Labor input

The key of constructing the labor input is to convert heterogeneous hours worked into homogenous volume of labor input by the method described in detail in Jorgenson et al. (2005, chapter 6). Wu et al. （2015a）introduced the detailed process of constructing the labor input series in China.

According to Jorgenson et al. (2005), the relationship between the labor input and hours worked can be expressed as $L_{lit} = Q_l H_{lit}$ (38) , where L_{lit} is labor input of type l for industry i , H_{lit} is worked hours of type l for industry i, Q_l is the proportionality factor.

The labor input for sector can be attained by Tornqvist aggregate of different type of labor inputs for the sector.

(39) $$\Delta \ln L_{it} = \sum_l \bar{v}_{lit} \Delta \ln L_{lit} = \sum_l \bar{v}_{li} \Delta \ln H_{lit}$$

(40) $$v_{li} = \frac{P_{L,li} L_{li}}{\sum_l P_{L,li} L_{li}}$$

Where v_{li} is the share of labor input of type l for industry i in the value of labor input for industry i , $P_{L,li}$ is the price of labor input of type l for industry i .

5. EMPIRICAL ANALYSIS

In this section, using the framework developed in the previous sections and the sectoral data of CIP data set for 1980-2012, we calculate the contribution of sector-level resource misallocation to aggregate TFP growth. After measuring the distribution of sector-level frictions from data, we calculate reallocation effect term (*RE*) and the share of RE in aggregate productivity growth (*ATFP*). We also estimate the output loss between the real output and the potential output when all the inputs are allocated efficiently. Then we identify which sector is the cause of the distortions and explore the industry origin of the reallocation effect.

Relative distortion coefficients of input

Using (20), we calculate relative distortion coefficients of capital and labor for industries. The average results from 1980 to 2012 are shown in Table 1, we can see the distortion degree of factors' price varied largely across industries. As discussed above, if $\tilde{\lambda}_{Ki} > 1$ or $\tilde{\lambda}_{Li} > 1$, which means the relative cost of capital or labor input in this industry is low, this industry has the incentive to overuse the capital or labor input; if $\tilde{\lambda}_{Ki} < 1$ or $\tilde{\lambda}_{Li} < 1$, which means the relative cost of capital or labor input in this industry is high, this industry has the incentive to underuse the capital or labor input.

According to table1, we see some industries overuse capital input, such as Real Estate Activities (CIP32), Financial Intermediation (CIP31), Public Administration and Defense (CIP34), Transport, Storage & post (CIP29), Tobacco products (CIP7) and Agriculture (CIP1), while some industries underuse capital input, such as Leasing, Technical, Science & Business Services (CIP33), Information & computer services (CIP30) and Coal mining (CIP2). At the same time, we see some industries overuse labor input, such as Agriculture (CIP1), Non-metallic minerals mining (CIP5), Apparel and other textile products (CIP9), Leather and leather products (CIP10), Saw mill products, furniture, fixtures (CIP11), Food and kindred products (CIP6), while some industries underuse labor input, such as Financial Intermediation (CIP31), Real Estate Activities (CIP32), Leasing, Technical, Science & Business Services (CIP33).

In order to explore the dynamic evolvement of distortion of price of factor inputs, we show the relative distortion coefficient of input for some part of industries from 1980 to 2012. During more than 3 decades of reform, there are some big events or change of policy which have deep influence to Chinese economy. China leased reform and opening-up after 1978, Deng's famous southern china trip in 1992 to promote bolder reform, China's WTO entry at the end of 2001 and the global financial crisis in 2008-09. We use the previous year of the major event as the base for the estimation for that period except using the start point of our sample as the base of first period.

TABLE 1

THE AVERAGE OF RELATIVE DISTORTION COEFFICIENTS OF CAPITAL AND LABOR FOR INDUSTRIES（1980-2012）

CIP No	Industry	$\tilde{\lambda}_{Ki}$	$\tilde{\lambda}_{Li}$	CIP No	Industry	$\tilde{\lambda}_{Ki}$	$\tilde{\lambda}_{Li}$
1	AGR	1.89	1.46	20	ELE	0.94	0.77
2	CLM	0.43	0.54	21	ICT	0.95	0.57
3	PTM	0.64	0.37	22	INS	1.02	1.07
4	MEM	0.58	0.46	23	TRS	0.90	0.55
5	NMM	0.68	1.68	24	OTH	1.33	1.88
6	FDB	0.71	1.21	25	UTL	1.04	0.36
7	TBC	1.57	0.38	26	CON	0.84	0.69
8	TEX	0.84	0.91	27	SAL	0.67	1.21
9	WEA	0.93	1.53	28	HOT	1.13	1.03
10	LEA	0.76	1.43	29	T&S	1.53	0.80
11	WDF	0.70	1.44	30	P&T	0.53	0.85
12	PAP	0.91	0.91	31	FIN	1.77	0.32
13	PET	0.89	0.34	32	REA	2.09	0.35
14	CHE	1.06	0.48	33	BUS	0.52	0.28
15	RBP	0.83	1.23	34	ADM	2.02	0.44
16	BUI	0.79	0.80	35	EDU	1.08	0.89
17	MSP	0.95	0.38	36	HEA	0.86	0.91
18	MPD	0.91	1.07	37	SER	0.86	3.42
19	MCH	0.68	0.51				

Source: Authors' estimation.

For the evolvement of relative distortion coefficient of capital (Table 2), $\tilde{\lambda}_{Ki}$ of Financial Intermediation continuously decrease from 2.91 in 1980-1991 to 1.28 in 2001-2007, which imply the distortion and overuse of capital had been weakened, however, the overuse condition has been reversed to underuse after global financial crisis. For some industries (Real Estate Activities, Public Administration and Defense, Transport, Storage & post), $\tilde{\lambda}_{Ki}$ continuously increase over the past 3 decades, which means the distortion and overuse of capital had been deteriorated. Agriculture underused capital input for the first decades after reform, however, it turned to overuse capital input and kept the growing tendency after Deng's southern china trip. Tobacco products also underused capital input for the first decades after reform, and then it overused capital input most between 1991 and 2001, $\tilde{\lambda}_{Ki}$ finally decreased from 2.36 in 1991-2001 to 1.43 in 2007-2012. All of three industries which have average $\tilde{\lambda}_{Ki}$ less than one almost show continuous decrease of $\tilde{\lambda}_{Ki}$ for the whole period, which implies the distortion of and underuse of capital had been deteriorated.

TABLE 2

THE RELATIVE DISTORTION COEFFICIENT OF CAPITAL FOR SOME INDUSTRIES（1980-2012）

Industry	**1980-1991**	**1991-2001**	**2001-2007**	**2007-2012**
Financial Intermediation	2.91	1.46	1.28	0.49
Real Estate Activities	1.00	1.92	3.40	3.23
Public Administration and Defense	1.75	1.15	2.66	3.58
Transport, Storage & post	1.11	1.50	1.87	2.11
Tobacco products	0.70	2.36	2.00	1.43
Agriculture	0.97	1.07	2.75	4.52
Leasing, Technical, Science & Business Services	0.92	0.45	0.18	0.22
Information & computer services	0.96	0.42	0.25	0.17
Coal mining	0.70	0.44	0.17	0.12

Note: average relative distortion coefficient for each period

For the evolvement of relative distortion coefficient of labor (Table 3), $\tilde{\lambda}_{Li}$ of Agriculture has been always more than one, but grown in the first two decades and then decreased to the starting level. For some industries(Non-metallic minerals mining, Food and kindred products), $\tilde{\lambda}_{Li}$ continuously decreased over the past 3 decades from more than one to less than one, which means these industries made transition from overuse of labor input to underuse of labor input. For Apparel and other textile products, $\tilde{\lambda}_{Li}$ has been always more than one, but decreased from 2.06 to 1.02 for the first 2 decades and then grown to 1.49 after the global financial crisis, thus the distortion of labor was weakened first and then deteriorated. For some industries (Leather and leather products, Saw mill products, furniture, fixtures), $\tilde{\lambda}_{Li}$ of them were as high as 1.76 and 2.21 during the first decade after reform, but then decreased to keep mildly more than one, which implies the distortion and overuse of labor had been weaken with the reform. For some industries that underuse labor, e.g. Financial Intermediation and Leasing, Technical, Science & Business Services, the distortion and underuse of labor has been weaken during the whole period. For Real Estate Activities, $\tilde{\lambda}_{Li}$ continuously increased from 0.11 to 0.47 until the global financial crisis, and then increased to more than one that implies overuse of labor.

TABLE 3

THE RELATIVE DISTORTION COEFFICIENT OF LABOR FOR SOME INDUSTRIES（1980-2012）

Industry	**1980-1991**	**1991-2001**	**2001-2007**	**2007-2012**
Agriculture	1.28	1.68	1.60	1.24
Non-metallic minerals mining	2.92	1.22	0.88	0.85
Food and kindred products	1.91	1.00	0.70	0.69
Apparel and other textile products	2.06	1.02	1.44	1.49
Leather and leather products	1.76	1.13	1.43	1.32
Saw mill products, furniture, fixtures	2.21	1.01	1.01	1.11
Financial Intermediation	0.35	0.13	0.34	0.60
Real Estate Activities	0.11	0.09	0.47	1.22
Leasing, Technical, Science & Business Services	0.20	0.21	0.34	0.50

Note: average relative distortion coefficient for each period

Decomposition of aggregate TFP

Using (25) ,we calculate the aggregate TFP growth rate (*ATFP*), sectoral TFP term (*STFP*) and reallocation effect term (*RE*). In order to analyze the effect of some big events, we also estimate the average value for the whole period and the same sub-periods as above (Table 4). For the past 3 decades, the average aggregate TFP growth rate is 0.94%, sectoral TFP term is 0.64% that accounts for 68% of source of aggregate TFP growth, and reallocation effect term is 0.29% that accounts for 32% of source of aggregate TFP growth. So the driving force of productivity growth of the whole economy is the productivity growth of individual industry for the past 3 decades, and the reallocation of resources also has important role to improve the productivity of economy, thus it means the reform weak the misallocation of resources.

Just like Wu et al. (2015b), the first decade after reform did trigger a significant *RE* (0.67%) thanks to the deregulation and decentralization measures that greatly improved the incentives of economic agents and the allocation of resources. However, the *STFP* (0.58%) is less than *RE* during this period, since the economy shift to more labor-intensive technologies that were in line with China's comparative advantage at first stage leaving from central planning regime. What is more, a severe shortage of investment funds in that period could be another reason for the slow improvement in productivity of individual industry.

After Deng's southern china trip, China took deeper reforms and relaxed financial constraints compared with the past periods thanks to the early reforms. With a stronger urge to catch up during the economic restructuring, the government re-emphasized the role of the state firms in "strategic industries" and engineered the growth through various subsidies and interventions. This change could be reflected by an unprecedented gain in *STFP* of 1.72% average for this period, meanwhile, *RE* turned into -0.52% average for this period, which is well in line with our story that government-engineered technological progress tends to suffer from severe efficiency loss.

After access to WTO, not only export of China grown rapidly, but import competition also became intensive. Adding exposure to export market and more intensive competition improved the reallocation of resources, especially labor reallocation for export-oriented, labor intensive industries. However, the comprehensive reform of housing system in 1998 stimulated the real estate sector to develop rapidly and housing price attain unprecedented rise , while the productivity of this sector are lower (Chen et al., 2015). Meanwhile, unlike the prediction of standard international trade model of heterogeneous firms (Melitz, 2003), the productivity of export firms significant less than that of non-export firms in china (Lu,2010; Lu et al., 2010) , thus the productivity for individual industry would be lower. This situation could be reflected by highest *RE* (1.06%) across all the sub-periods, and *STFP* of 0.54% that less than past decade.

The global financial crisis brought shock of productivity to firms, central and local governments released the unprecedented fiscal stimulus package in order to keep the growth rate of economy. The role of SOEs and intervene of government were enhanced substantially after this financial crisis. Thus we find *STFP* substantially turn to negative (-1.25%), while we find the reallocation of resources become worse and RE decline although still keep positive (0.18%).

TABLE 4

DECOMPOSITION OF AGGREGATE TFP GROWTH RATE(%)

	1980-1991	1991-2001	2001-2007	2007-2012	1980-2012
ATFP	1.25	1.19	1.60	-1.07	**0.94**
STFP	0.58	1.72	0.54	-1.25	**0.64**
RE	0.67	-0.52	1.06	0.18	**0.29**

Note: average value for each period

In order to explore the contribution of primary factors to reallocation effect, we further investigate *RE(K)* and *RE(L)*(Table 5). For the whole period, the positive reallocation effect (0.29%) is driven by the positive reallocation effect of labor (0.52%), while the reallocation effect of capital is negative (-0.22%). Since the reform released, China has experienced a massive labor migration from agriculture to industry and service, industry to service. Most of which is going from low TFP sector to high TFP sector. This kind of reallocation should help to reduce the differences in returns to labor across sectors and therefore the misallocation of labor. On the contrary, the stylized characteristic of Chinese economy for past 3 decades is the high speed growth of gross output with high investment driven, but the misallocation between SOEs and Non-SOEs are significant during the period, that SOEs are less productive on average and have better access to external credit than Non-SOEs (Song et al., 2011; Hsieh and Klenow, 2009; Dollar and Wei, 2007).

At the early reform stage, the decollectivization in agriculture and planning-market double track price reform with more operational autonomy in the industrial sector has improve the reallocation effect for both capital and labor input, thus we could see positive *RE(K)* (0.33%) and *RE(L)* (0.34%) during this period. With the government re-emphasized the role of the state firms in “strategic industries” and engineered the growth through various subsidies and interventions (especially SOEs were preferable to access to credit market), the misallocation of resources (especially for capital) were largely deteriorated, which reflected by negative *RE(K)* (-0.52%) and *RE(L)* (-0.01%).

China experienced mixed change after entering WTO. On one hand, adding exposure to export market and more intensive competition improved the reallocation of labor for export-oriented, labor intensive industries; On the other hand, the rapid development of real estate sector and rising of housing price absorbed large amount of investment, which brought in plenty of distortion caused by various subsidies and financial frictions. The performance of reallocation effect of capital and labor reflected these changes, that *RE(K)* is -0.66% and *RE(L)* is 1.72%. Besides, we do not find a worse capital reallocation effect over the global financial crisis period. Its decline somewhat slowed down (-0.31%) despite unprecedented fiscal injection benefitting mainly state-owned enterprises and state-controlled industries, which is consistent with Wu (2015b). Meanwhile, the reallocation effect of labor slowed down to 0.49%, since the labor-intensive exporters suffered the shock of financial crisis.

TABLE 5

DECOMPOSITION OF REALLOCATION EFFECT TERM (%)

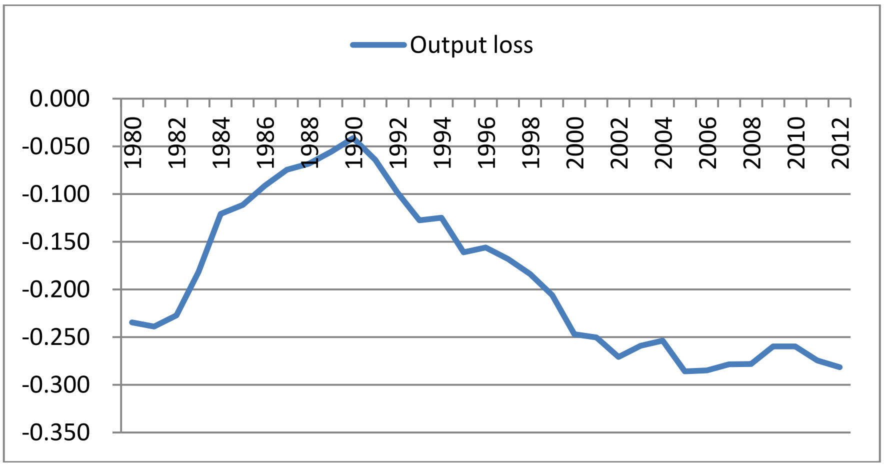
	1980-1991	1991-2001	2001-2007	2007-2012	1980-2012
RE	0.67	-0.52	1.06	0.18	**0.29**
RE(K)	0.33	-0.52	-0.66	-0.31	**-0.22**
RE(L)	0.34	-0.01	1.72	0.49	**0.52**

Output loss between real output and potential output

Using (27), we calculate the output loss (also TFP loss) between real output and potential output. The result is shown in Figure 1, we find the output loss are shift between -4.1% (1990) and -28.6% (2005), which illustrates that there has been persistent misallocation of factors during past 3 decades. At the early stage, the output loss is large to -23.4% (1980), since the misallocation of resources and the disincentives of the central planning system persisted. During the first decade after reform, we see the degree of output loss continuously decrease from -23.4% (1980) to -4.1% (1990), which also thanks to the deregulation and decentralization measures that greatly improved the incentives of economic agents and the allocation of resources. Between Deng's southern china trip and the eve of global financial crisis, although the "socialist market economy" was officially accepted by government and China accessed to WTO, the government re-emphasized the role of the state firms in "strategic industries" and engineered the growth through various subsidies and interventions, especially by distorting reallocation of capital across SOEs and Non-SOEs, thus we see degree of output loss continuously increase from -4.1% (1990) to -27.9% (2007). After global financial crisis, the degree of output loss decreased first and then increased, we guess the crisis gave shock to potential production frontier so that the gap between real output and potential output narrowed from 2008 and 2010. On the contrary, the gap between real output and potential output widened again from 2010 to 2012, on one hand, the potential production frontier shift outward with the degree of financial crisis weaken; on other hand, the unprecedented fiscal injection has taken effect so that the misallocation of resources deteriorated(*RE* shift from 0.26% (2010) to -0.58% (2012)). Also, the trend of output loss we estimated is consistent with that estimated by Brandt et al. (2013) for the period 1985-2007.

FIGURE 1

OUTPUT LOSS BETWEEN REAL OUTPUT AND POTENTIAL OUTPUT



Output loss, on one hand, reflected the loss of efficiency caused by misallocation, on the other hand, reflected the growth potential by correcting the distortion. According to the estimation of 2012, we can improve the output or TFP more than 28.2% based the real output or TFP, which is the great growth potential if China take further reform. Comparing with the estimation by Hsieh and Klenow (2009), our estimation approaches the lower bound of their estimation (30%-50%). We guess the difference come from two points: First, we use the real Chinese data to estimate the coefficients of gross output production function rather than using coefficients of value added production function from US; Second, we adopt the input-output data for whole economy including agriculture and service sectors rather than use data only for industry. Also the result estimated by Brandt et al. (2013) for non-agricultural economy is around 20% that lower than Hsieh and Klenow (2009).

Contribution of each sector to RE

In this section, we analyze which sector contributes to reallocation effect (*RE*) by using the method illustrated in section 2.7. Owing to the space limitation, we only show the average *RE(i), RE(Ki)* and *RE(Li)* of all sectors for the whole period in Table 6.

TABLE 6

THE AVERAGE OF *RE*, *RE(K)* AND *RE(L)* FOR INDUSTRIES （1980-2012）(%)

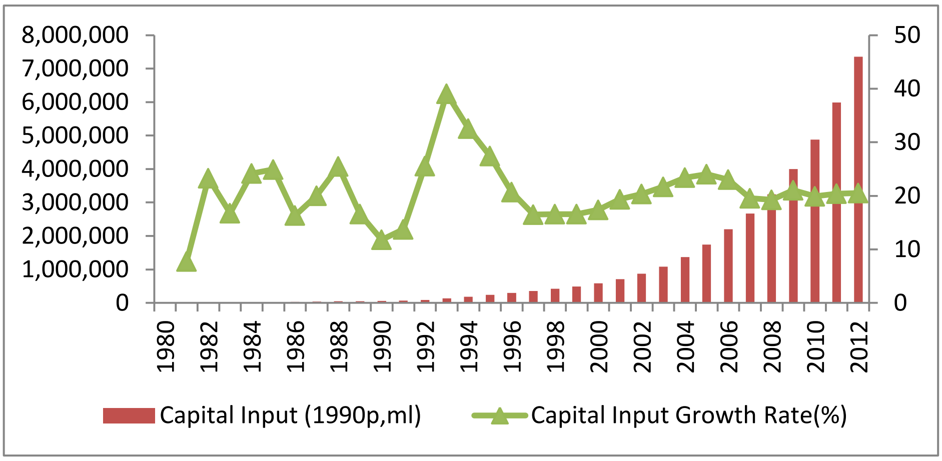
CIP No	Industry	*RE*	*RE(K)*	*RE(L)*	CIP No	Industry	*RE*	*RE(K)*	*RE(L)*
1	AGR	0. 3705	0. 0112	0. 3593	20	ELE	0. 0076	0. 0037	0.0039
2	CLM	−0. 0029	−0. 0059	0. 0029	21	ICT	0.0302	0. 0102	0.0200
3	PTM	0. 0025	+0. 0000	0. 0025	22	INS	-0.0003	+0. 0000	-0.0003
4	MEM	0. 0034	0. 0027	0. 0007	23	TRS	0.0095	0. 0014	0.0081
5	NMM	−0. 0065	−0. 0063	−0. 0002	24	OTH	-0.0126	−0. 0148	0.0021
6	FDB	−0. 0019	−0. 0016	−0. 0003	25	UTL	0.0123	0. 0020	0.0103
7	TBC	0. 0447	0. 0450	−0. 0003	26	CON	0.0559	−0. 0098	0.0657
8	TEX	0. 0160	0. 0172	−0. 0012	27	SAL	-0.0238	−0. 0394	0.0156
9	WEA	−0. 0031	−0. 0021	−0. 0010	28	HOT	-0.0024	−0. 0034	0.0010
10	LEA	−0. 0029	−0. 0024	−0. 0005	29	T&S	-0.0104	−0. 0100	-0.0004
11	WDF	0. 0075	−0. 0003	0. 0078	30	P&T	-0.0173	−0. 0235	0.0062
12	PAP	−0. 0002	−0. 0007	0. 0005	31	FIN	0.1044	0. 0482	0.0561
13	PET	0. 0052	0. 0024	0. 0028	32	REA	-0.2476	−0. 2937	0.0461
14	CHE	0. 0095	0. 0053	0. 0042	33	BUS	0.0668	0. 0184	0.0484
15	RBP	0. 0019	0. 0015	0. 0004	34	ADM	0.0724	−0. 0342	0.1066
16	BUI	−0. 0125	−0. 0044	−0. 0081	35	EDU	0.0083	0. 0018	0.0066
17	MSP	0. 0126	0. 0104	0. 0022	36	HEA	0.0032	0. 0023	0.0009
18	MPD	−0. 0007	−0. 0001	−0. 0006	37	SER	-0.0683	0. 0068	-0.0751
19	MCH	−0. 0253	−0. 0204	−0. 0048					

Note: The positive 0.0000 means value is positive but runs to 0.

We find from table 6 that agriculture(CIP1) and real estate(CIP32) sectors explain most of the *RE*. First, let us focus on the agriculture sector. The *RE* of agriculture is 0.37% per annum for average, and the main contribution comes from the *RE(L)* that is 0.36% per annum for average, while the contribution comes from the *RE(K)* is negligible. Although agriculture still received various subsides, it is no longer subject to administrative controls after reform launched. The mobility of labor between agriculture sector and non-agriculture sector improved largely during past 3 decades, and large amounts of surplus labor in village has been transferred to urban district into service and construction sectors, thus the change improved the efficiency of reallocation of resources and weakened the overuse of labor input in agriculture sector, which significantly contributed positive to the reallocation effect and productivity growth of whole economy. However, the overuse of labor input in agriculture ($\tilde{\lambda}_{Li}$ is 1.206 in 2012) is need to improve further, if China could weaken the barriers of hindering the mobility of labor form agriculture to non-agriculture, it will attain more efficiency gain (Yuan and Xie, 2011).

FIGURE 2

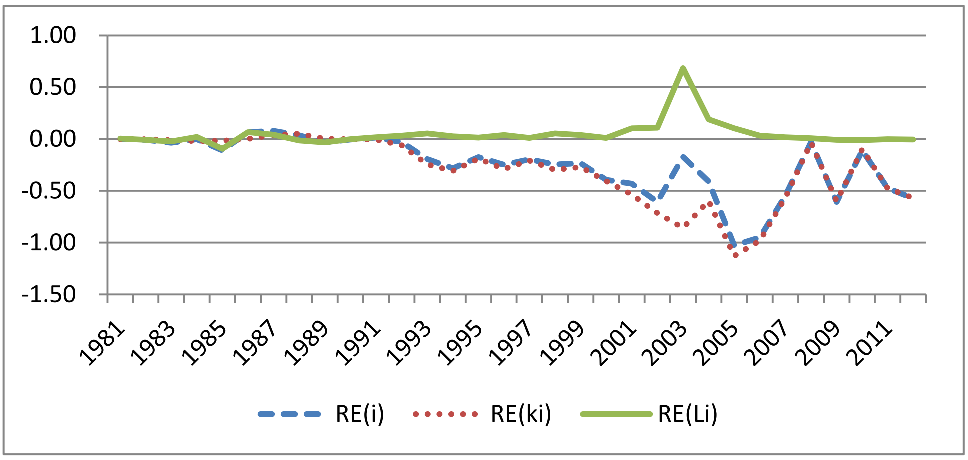
CAPITAL INPUT AND ITS GROWTH RATE FOR REAL ESTATE SECTOR



Note: The data comes form CIP data set

Second, let us focus on the real estate sector. The *RE* of real estate is -0.25% per annum for average, and the main contribution comes from the *RE(K)* that is -0.29% per annum for average, while the contribution comes from the *RE(L)* is relative small as 0.05%. The housing system was beginning to reform from 1988, and the real estate largely opened to market dating from the comprehensive reform of housing system in 1998 (Xu et al., 2015), then it gradually became "strategic industry" to economic growth and source of finance of local governments. A lot of subsidies and accessing to credit market easily to impulse the investment in real estate sector, thus we can see the capital input increased rapidly from 1998 (Figure2), but so much government intervenes distorted largely the reallocation of capital input until the broken out of global financial crisis, and then unprecedented fiscal injection deteriorated the misallocation of capital again (Figure3). Also the rapid growth of housing price beginning from 2003 absorbed large amount of investment into real estate sector, which cause the severe misallocation of capital (Chen et al., 2015).

FIGURE 3
RE, RE(K) AND RE(L) FOR REAL ESTATE SECTOR

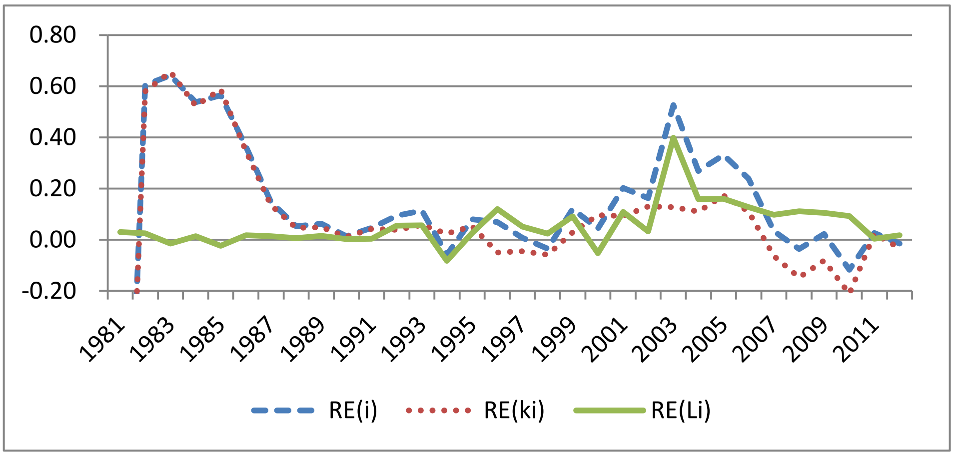


Also, financial intermediation sector has obvious contribution to the reallocation effect of economy. The *RE* of financial intermediation is 0.1% per annum for average, and both the reallocation of capital and the reallocation of labor have played important role to the improvement of reallocation efficiency of this sector, where *RE(K)* is 0.05% per annum for average and *RE(L)* is 0.06% per annum for average. During the early stage after the reform, the highly centralized financial system with People's Bank of China(PBOC) functioned as both central bank and the only commercial bank was transformed into a two-tier system when the four state-owned commercial banks (the Big Four) were formally established, following economic reforms until the Asian financial crisis, the establishment of new banks and other financial institutions became a source of competition in the financial sector, the reallocation efficiency of capital improved largely during this time (Figure 4) since banks were more efficient in allocating resources than state budgetary appropriation (Cull and Xu, 2000).

The Asian financial crisis deteriorated the reallocation of capital for financial intermediation sector. The years after China formally entered the WTO were characterized by an impressive financial liberalization process, including more interest rate liberalization, less restrictions on ownership takeovers, and greater freedom to foreign banks, etc. Financial liberalization and marketization of resource allocation steadily improved the productivity of reallocation of primary factors for financial intermediation sector (Figure 4), which is consistent with the result by Zhang et al.(2012). Although the financial reform has contributed positive to economic growth of China, the misallocation of financial intermediation sector still severe owing to ownership structure and size structure of banking system(Lin et al., 2015), more action should be taken to promote small banking institutions in the Chinese banking sector.

FIGURE 4

RE, RE(K) AND RE(L) FOR FINANCIAL INTERMEDIATION SECTOR



To investigate the reallocation effect of industries located in different positions of the production chain which are subject to different degrees of government intervention or different types of government subsidies, we categorize the 37 industries into eight groups illustrated in detail by Wu(2015b) (see Table A1). 24 industries of the industrial sector are divided into three groups, namely "energy", "commodities and primary input materials(C&P)", and "semi-finished and finished goods(SF&F)". According to their "distances" from the final demand, the "energy" group stays on the top of the production chain, which is followed by "C&P" in the middle and "SF&F" closest to end market. Next, services are divided into three groups with Services Ⅰ consisting of state-monopolized services, i.e. financial intermediaries, transportation, and telecommunication services, Services Ⅱ covering the rest of market services and Services Ⅲ of SNA defined "non-market services" including government administration, education and healthcare.

We start with an examination of reallocation effect of primary factors by industry group for sub-periods as reported in Table 7. Just like the case for average reallocation efficiency shown above, China's agriculture achieved the best reallocation effect performance of all groups. The early stage (1978-1984) after reform, decollectivization and adjustment in state procurement prices contributed positively to productivity improvement in agriculture (Lin, 1992), and township enterprises developed so rapidly after 1984 that they absorbed lots of excess agricultural labors since they were not constraint with Household registration system (Yuan and Xie,2011) . After Deng's famous southern trip, more excess agricultural labors were transferred to non-agricultural sectors with the deeper reforms, thus the *RE(L)* and *RE* attained better performances. When china accessed to WTO, so rapid growth of export and more foreign direct investment provided huge demand for excess agricultural labors to migrate to non-agricultural sectors, which lead the best performance of reallocation efficiency across all sub-periods and industry groups. Although the global financial crisis deteriorated the degree of reallocation effect, the performance still restored the level of the first decade after reform.

TABLE 7

REALLOCATION EFFICIENCY OF RESOURCES IN CHINA BY INDUSTRY GROUP

	RE	*RE(K)*	*RE(L)*	*RE*	*RE(K)*	*RE(L)*
	1980−1991			1991−2001		
Energy	0.04	0.03	0.02	−0.06	−0.03	−0.03
C&P	0.09	0.08	0.01	−0.08	−0.02	−0.06
SF&F	0.17	0.15	0.02	−0.21	−0.17	−0.04
Services I	0.11	0.10	0.01	0.00	−0.04	0.04
Services II	0.02	0.01	0.01	−0.47	−0.33	−0.14
Services III	0.05	0.00	0.05	0.02	0.00	0.02
Agriculture	0.21	−0.01	0.22	0.34	0.02	0.31
Construction	0.13	−0.01	0.14	0.05	0.00	0.05
	2001−2007			2007−2012		
Energy	0.10	0.00	0.10	0.02	−0.01	0.03
C&P	0.05	0.00	0.05	0.04	0.03	0.01
SF&F	0.20	0.05	0.15	0.15	0.08	0.07
Services I	0.25	0.06	0.19	−0.05	−0.11	0.06
Services II	−0.57	−0.91	0.34	−0.18	−0.26	0.09
Services III	0.36	−0.08	0.44	−0.04	−0.10	0.05
Agriculture	0.85	0.06	0.79	0.21	−0.02	0.23
Construction	−0.02	−0.02	0.00	0.00	−0.02	0.02

Note: average annual growth rate in percent for each period

The “semi-finished and finished ” and “commodities and primary input materials” groups are well-known as China’s growth engines and the backbone of the “world factory”. Compare to “C&P”, “SF&F” received much less government direct interference due to its competitive nature and more exposure to the international market (Wu, 2015b). We find that “SF&F” in general fulfilled better performance of reallocation efficiency than “C&P”. The planning –market double track price reform during the first decade after reform improved the reallocation effect of resource (especially for capital). The catch up strategy in 1990s made the government re-emphasized the role of the state firms, which deteriorated largely the reallocation effect of resources for some “strategic industries” such as Industrial machinery and equipment sector (*RE* is -0.11%), thus we see RE of “SF&F” less than RE of “C&P” during this period. WTO-induced deeper opening up to foreign trade improve the reallocation effect of labor for labor-intensive industrial sectors, the effect is significant for “SF&F” is more labor-intensive than “C&P”. Nonetheless, in the wake of the crisis, both suffered from the decline of reallocation effect of labor.

Comparing with the relative downstream industrial groups “C&P” and “SF&F”, “energy” group is monopolized by large, central government-owned enterprises due to its “strategic importance”. It can easily access to public resources but subject to strong administrative interferences (Wu, 2015b). It is reflected by the *RE(K)* of “energy” is in general less than that of the other two groups, while the tendency of reallocation effect of resources is the same with that of the other two groups. Construction sector kept improvement of *RE(L)* during the first two decades after reform due to decollectivization in agriculture and SOE reform increased mobility of labor. With the rapid increase of housing price after China accessed to WTO, the construction sector expanded rapidly also brought about misallocation of capital.

The performance of reallocation effect of all service sectors are good in the 1980s, since China corrected the deregulations over the long suppressed service development under central planning. The performance for Services I and ServicesⅢ are better due to they received more intervene by government before the reform than ServicesⅡ. In the 1990s, reform of financial intermediation and telecommunication improved the competition and weakened the misallocation in Services I, which offset the negative reallocation effect of capital for Transport, Storage & post sector that strengthened the control by government. Owing to the rapid development of real estate brought severe misallocation of capital, the performance of reallocation of resources for ServicesⅡ are bad. However, the "non-market service" sectors improved their productivity of reallocating labor in order to suit for the construction of "socialist market economy". When China accessed to WTO, the deep opening up to foreign trade improve the reallocation effect of labor for all the service sectors, and ServicesⅡand ServicesⅢ had better performance of *RE(L)* since they are more labor-intensive than Services I. Meanwhile, growing FDI stimulated the deeper reform of financial and Telecommunication, and IT industry characteristic with high technology also developed rapidly , thus *RE(K)* for Services I is positive (0.06%). However, the high speed increase of housing price caused the severe misallocation of capital to real estate, thus it reflected the worst performance of *RE* and *RE(K)* for ServicesⅡacross all groups and sub-periods. The global financial crisis and fiscal stimulus package thereafter deteriorated the reallocation of resource for all service sectors, and *RE(K)*s are negative and *RE(L)*s are still positive.

6. TESTING FOR INSTITUTIONAL ARGUMENT

We then investigate the influence of some important institutional factors to the resource reallocation. We choose reallocation efficiency (*RE*) and their two decompositions (*RE(K)* , *RE(L)*) of each industry as the dependent variables, which can capture the dynamic change of resource allocation across industries. We construct panel date which covers 37 industries during 1981-2010 to do the regression exercise. Since reallocation effect is a growth rate, the first year (1980) of CIP data is neglected. The explanatory variables have still not constructed for 2011-2012, thus we don't include the data for these two years. To our knowledge, this is the first study which systematically explores the institutional explanation of misallocation problem for the whole economy rather than some part of industries.

In the following econometric specification, we first consider a variable that may better capture the ownership effect. In the literature, state owner enterprises(SOE) have worse productivity performance but easier access to resource, especially credit at financial market (Hsieh and Klenow,2009; Brandt et al., 2013). In this exercise we adopt SOE ratio of employment in each industry, denoted as *SOE*, to illustrate the effect of SOE to resource reallocation. We expect *SOE* to be significantly negative.

Next, we consider the effect of export-oriented policy to the resource reallocation. According to classical theory (Melitz, 2003), export can improve productivity performance through selection effect and competition effect; However, indirect subsidies have been used by local governments to promote exported manufactures has also caused misallocation. We use export ratio of gross output in each industry, denoted as *EXP*, to illustrate the effect of export-oriented policy to resource reallocation. The sign of the coefficient depends on which mechanism that mentioned above dominated the other.

Our third institutional variable reflects the effect of government intervention, which can improve economic growth but cause resource misallocation (Huang, 2012; Wu et al., 2015b; Wu,2015b; Xu, 2011) . Tax income is the key indicator that lead to government intervention. Thus we construct production tax ratio of value added in each industry, denoted as *TAX*, to capture the role of government intervention. We expect *TAX* to be significantly negative.

These hypotheses raised above are based on studies mainly focus on industrial sectors, but the characteristics of industry and non-industry are quite different. Thus in our exercise, we add dummy variable non-industry, denoted as *NOI*, to explore the different influential pattern of institutional variables for different groups. In the regression model, we construct three cross items: *SOE_NOI*, *EXP_NOI* and *TAX _NOI* . What is more, we adopt lagged form of these explanatory variables owing to the dependent variables are change rate from last year to present. Finally, we control time tendency and fixed effect of each industry. Our benchmark regression model is expressed as model 1 below (*y* represents RE, RE(K), RE(L)).

$$y_t = \beta_0 + \beta_1\, SOE_{t-1} + \beta_2\, EXP_{t-1} + \beta_3\, TAX_{t-1} + \beta_4\, SOE_{t-1} * NOI + \beta_5\, EXP_{t-1} * NOI + \beta_6\, TAX_{t-1} * NOI + \beta_7 t + \varepsilon_t \quad (Model\ 1)$$

In order to investigate the effect of big reform events, such as “access to WTO” and “grabing the big and freeing the small” state-owned enterprises reform, we added two dummy variables to stand for these reforms: *WTO*(1, if during 2002 and 2007; 0, otherwise) stands for the period from china accessed to WTO to global financial crisis broke out; *Y1999* (1, if after 1999; 0, otherwise) stands for the period after china formally announced policy change “grabing the big and freeing the small” in 1999 in the Fourth Plenum of the Communist Party’s Central Committee(Hsieh and Song, 2015). We use the cross item variable “*EXP_WTO*” to explore whether the impact of export ratio to reallocation efficiency different before against after China accessed to WTO, at the same time, we use the cross item variable “*SOE_Y1999*” to explore whether the impact of SOE ratio to reallocation efficiency different before against after China lunched state-owned enterprises reform. As discuss above, we adopt lagged form of these explanatory variables, thus we extend model 1 to model 2.

First, the results of model 1 and model 2 are robust. The impact of SOE ratio to RE is negative for sectors of industry, that is consistent with many previous works (Brandt et al., 2013; Hsieh and Klenow,2009) . When we look into deeper level of reallocation of capital and labor, we find SOE ratio is related negatively to RE(K). The presence of systematic distortions in capital allocation across firm ownership has been illustrated by plenty of research (Dollar and Wei, 2007; Hsieh and Klenow, 2009) that focusing on China’s industry sectors, even after more than 30 years reforms, state-owned firms still have significantly lower returns to capital and access to credit easier and cheaper, thus we can see the industry of which SOE ratio higher has lower reallocation effect of capital. However, we find the impact of SOE ratio to RE(L) is positive for sectors of industry. With the reform of state owned enterprises, the employment scale of SOE has continually decreased during the reform time (Yang, 2015) , at the same time, the labor productivity of SOE has converged to that of private firms (Hsieh and Song, 2015) , so we can see the SOE ratio has positive effect to reallocation effect of labor for industry.

TABLE 8

REGRESSION RESULTS

Dependent Variable:	Model 1 RE	Model 1 RE(K)	Model 1 RE(L)	Model 2 RE	Model 2 RE(K)	Model 2 RE(L)
SOE(-1)	-0.0631*** (0.00587)	-0.0920*** (0.00507)	0.0688*** (0.00413)	-0.0495*** (0.00467)	-0.0906*** (0.00531)	0.0534*** (0.00347)
EXP(-1)	-0.00280*** (0.000965)	-0.00481*** (0.00112)	-0.00209 (0.00399)	-0.00833*** (0.00181)	-0.00672*** (0.00126)	-0.00277*** (0.000732)
TAX(-1)	-0.0160*** (0.00147)	-0.0110*** (0.00179)	-0.00428 (0.00615)	-0.0220*** (0.00269)	-0.0122*** (0.00191)	-0.00885*** (0.00112)
SOE_NOI(-1)	0.357*** (0.0124)	0.216*** (0.00700)	0.213*** (0.0120)	0.367*** (0.0150)	0.211*** (0.00724)	0.182*** (0.00709)
EXP_NOI(-1)	0.144*** (0.0276)	0.0880*** (0.0111)	0.0982*** (0.0158)	0.149*** (0.0199)	0.0886*** (0.0111)	0.0875*** (0.0143)
TAX _NOI (-1)	0.245*** (0.0197)	0.0445*** (0.0141)	0.282*** (0.0178)	0.248*** (0.0271)	0.0443*** (0.0143)	0.261*** (0.0194)
SOE_Y1999(-1)				0.115*** (0.00624)	0.00363 (0.00286)	0.120*** (0.00366)
EXP_WTO(-1)				0.0337*** (0.00257)	0.00746*** (0.00179)	0.0245*** (0.000908)
t	0.000121 (0.000136)	-0.00133*** (0.000113)	0.00224*** (0.000142)	-0.000833*** (0.000108)	-0.00138*** (0.000117)	0.000820*** (0.0000799)
Fixed effect	yes	yes	yes	yes	yes	yes
Observations	1073	1073	1073	1073	1073	1073

Note: Both models are estimated using GLS for considering the correlation between groups and autocorrelation within group. Our regressions control the fixed effect for specific industries by introducing industry dummy variables. The unit of dependent variables is percent. Values in parentheses are standard errors. *** indicates statistically significantly different from zero at the 1% level; ** indicates 5% level; and * indicates 10% level.

It seems confusing that the impacts of SOE ratio to all of RE, RE(K) and RE(L) for non-industry sectors are positive. When we decompose non-industry sectors into agriculture, construction and service sectors, we find this positive effect comes from service sectors[5]. We will see the results are plausible if we take the structure of service department into consideration. The service department has been divided into producer services (Stanback et al.,1981; Marshall et al., 1987; Gruble and Walker, 1989; Coffey,2000) and consumer services. Producer services sectors including Financial Intermediation, Information & computer services and Leasing, Technical, Science & Business Services, etc. Wolff (2007) investigated 43 sectors during1960-2000 in US and indicated that productivity growth of producer service is consistent with that of industry while productivity growth of consumer service is nearly zero. Also there are some works manifested that producer services attained more productivity gain than consumer services in China (Wu, 2014; Cui and Wei, 2015; Tan and Zheng, 2012). In China, producer service sectors are dominated by

[5] In our exercises, we further adopt dummy variables of agriculture(AGR), construction(CON) and service(SER), allowing industry as benchmark to investigate the different pattern of impact for non-industry groups. If readers are interested in the results, you could ask for us.

some big state owned giants, while consumer service sectors are operated by some middle and small-sized enterprises and informal firms. That is why we can see SOE ratio of industry has positive impact on reallocation efficiency of both capital and labor for non-industry sectors. However, this result can not get the implication that SOE can improve the reallocation effect in non-industry sectors, which only illustrated the consequence of entry barrier of private firms in monopolized market service sectors.

The impact of EXP ratio to RE is negative for sectors of industry, we guess two reasons can explain this result. On one hand, the puzzle that the productivity of export firms significant less than that of non-export firms for industry sectors in china may cause the misallocation with the expansion of exporting scale. On other hand, the subsidy to export firms provided by government in order to encourage export also may cause the misallocation (Zhou et al., 2014), and subsidies are preferred to investment, which is reflected by the stronger negative effect to RE(K) than RE(L). The impact of EX ratio to reallocation resources for non-industry sectors are positive, which is consistent with the prediction by classical theory (Melitz, 2003).

For the political turnover of local government officers are positive correlated with the economic performance (Li and Zhou, 2005), the local government will choose idiosyncratic intervene or subsidies to different industries taking consider with the GDP performance and tax volume. Although the government intervene has great influence to the growth of China during the past three decades (Xu, 2011), it also bring about severe misallocation problems that cause inefficient performance of economy (Wu et al., 2015b), thus we can see the impact of TAX ratio to RE is negative for sectors of industry. Since the government intervene enterprises mainly through the channel of credit market, which is reflected by the impacts of TAX ratio to RE(K) and RE(L) are both negative but stronger for RE(K).

The impact of TAX ratio to RE is positive for non-industry sector. When we decompose non-industry sectors into agriculture, construction and service sectors, we find this positive effect comes from agriculture and service sectors. For agriculture, there was a long history that China suppressed development of agriculture to support development of industry, which caused severe gap of income for people work in agriculture against they work in non-agriculture. Market economy reform and Household registration system reform made excess labor in agriculture transferred to non-agriculture which improved the reallocation effect of agriculture. On one hand, the production tax is higher for agriculture, the larger income gap will accelerate the emigration of labor. On the other hand, with the Agricultural tax reform, the low production tax for agriculture means the high subsidy for agriculture, some part of subsidy only increase the wealth of farmer but not improve the production of agriculture, which slow down the excess labor in agriculture to be transferred to non-agriculture sectors and decrease the reallocation effect of agriculture. For service, we find the production tax ratio is in general higher for producer services than that for consumer services. We also illustrate above that producer services attained more productivity gain than consumer services in china, thus we think it is reasonable that the reallocation effect of resources are positively related to the TAX ratio of value-added for service sectors.

The effect of time trend to RE(K) is negative, while the effect of time trend to RE(L) is positive. The time trend of RE(K) is caused by governments distorting the allocation of capital, since they reshaped the role of "state-owned enterprises" after1990s and launched unprecedented fiscal injection after global financial crisis . On the contrary, the reform during the past 3 decades has eliminated largely the institutions that hindered the mobility of labor and “opening up” policy has improved the development of labor-intensive exporters which adopted the relative advantage, thus the reallocation effect of labor has been getting better performance with the time trend.

Comparing with benchmark regression models, we see the regression results of model 2 from column (4)-(6). We find the impacts of EXP to reallocation effect of capital and labor are significant larger when china accessed to WTO, which illustrates that accessing to WTO make Chinese firms closer to international market that improve the reallocation effect, and the more significant negative impacts of EXP to reallocation effect for industry sectors before china accessed to WTO further illustrate the key role of entering WTO. Meanwhile, we find the impacts of SOE ratio to reallocation effect of capital and labor are significant larger when china lunched state-owned enterprises reform, since “grabing the big and freeing the small” reform has efficiently improved the productivity of SOEs and thus improved the reallocation effect of the economy. Our results for state-owned enterprises reform are consistent with the TFP performance estimated by Hsieh and Song(2015) and Yang(2015), but our results are more comprehensive because not limited in the industry sectors and deeper because we explore further into reallocation of capital and labor.

TABLE 9

ROBUSTNESS CHECK

Dependent Variable:	Model 3 RE(K)	Model 3 RE(L)	Model 4 RE(K)	Model 4 RE(L)
SOE(-1)	-0.0924*** (0.00390)	0.0662*** (0.00623)	-0.0927*** (0.00394)	0.0378*** (0.00399)
EXP(-1)	-0.00490*** (0.00109)	0.00444 (0.00498)	-0.00680*** (0.00115)	-0.00252*** (0.000583)
TAX(-1)	-0.0111*** (0.00174)	-0.0102 (0.00782)	-0.0124*** (0.00177)	-0.0127*** (0.000936)
SOE_NOI(-1)	0.232*** (0.00425)	0.206*** (0.00909)	0.228*** (0.00435)	0.182*** (0.00894)
EXP_NOI(-1)	0.102*** (0.0126)	0.106*** (0.0109)	0.105*** (0.0126)	0.109*** (0.0149)
TAX _NOI (-1)	0.0426*** (0.0144)	0.289*** (0.0128)	0.0363** (0.0172)	0.259*** (0.0166)
SOE_Y1999(-1)			0.00874*** (0.00144)	0.124*** (0.00413)
EXP_WTO(-1)			0.00880*** (0.00145)	0.0248*** (0.000644)
RE(L)	-0.0623*** (0.00142)		-0.0634*** (0.00160)	
RE(K)		-0.0734*** (0.00344)		-0.0767*** (0.00286)
t	-0.00122*** (0.000108)	0.00223*** (0.0000949)	-0.00137*** (0.000103)	0.000618*** (0.0000536)
Fixed effect	yes	yes	yes	yes
Observations	1073	1073	1073	1073

Note: Both models are estimated using GLS for considering the correlation between groups and autocorrelation within group. Our regressions control the fixed effect for specific industries by introducing industry dummy variables. The unit of dependent variables is percent. Values in parentheses are standard errors. *** indicates statistically significantly different from zero at the 1% level; ** indicates 5% level; and * indicates 10% level.

There are maybe some unobserved variables can effect both RE(K) and RE(L). What is more, Based on their empirical work on the US economy in 1977-2000, Jorgenson et al. (2005) showed that the capital and labor reallocation effects generally moved in opposite directions. So we use the counterpart as dependent variable to do the robustness check. The results are shown in Table 9, model 3 corresponds to model 1, while model 4 corresponds to model 2.

The coefficients for explanatory variables RE(K) and RE(L) are significantly negative in both models, which are consistent with the finding by Jorgenson et al. (2005). Comparing the two corresponding groups, we don't find the main results from model1 and model2 change substantially.

7. Concluding Remarks

In this paper, we propose a gross output accounting framework that allows an industry-decomposition of the resource misallocation effect and an analysis of the industry effect on the aggregate total factor productivity (TFP) growth. The characteristic of this framework is that it could capture the multiplier effect of intermediate inputs by gross output approach introducing the Domar weights as in the Jorgenson model. Using the newly constructed China Industry Productivity (CIP) data set for 1980-2012, we explore the contribution of resource reallocation to China's aggregate TFP growth. We find that resource reallocation accounts for 0.29% to the aggregate TFP growth 0.94% on annual average from 1980- 2012, and reallocation effect of labor contributes for 0.52% on annual average while reallocation effect of capital contributes for -0.22% on annual average.

We further explore the industry origin of the reallocation effect by using counterfactual analysis just like Aoki (2012), and we find that agriculture sector is the primary source of reallocation effect of labor, RE(L) of which is 0.36% per annum for average. On the contrary, real estate sector is the primary source of reallocation effect of capital, RE(K) of which is -0.29% per annum for average.

Finally, We investigate the influence of some important institutional factors to the reallocation effect of resources. We verify that ownership, export-oriented policy and government intervention actually account for reallocation effect of resources. However, the patterns of impact varied between industry sectors and non-industry sectors. Also some big reform events, such as "access to WTO" and "grabing the big and freeing the small" state-owned enterprises reform, significantly improved the reallocation effect of whole economy.

The present work is still subject to some limitations. First, this paper takes into account the role of intermediate inputs just through the multiplier effect of linkage, it does not consider the misallocation of intermediate inputs themselves. We know frictions on the allocation of intermediate inputs actually exist due to idiosyncratic industrial policy, there must be effects on aggregate productivity. Second, the results in this paper depend on the details of data, we should take more strict the heterogeneity of capital and labor inputs into consideration. Explorations of theses issues are also left for future.

APPENDIX
TABLE A1
CIP/CHINA KLEMS INDUSTRIAL CLASSIFICATION AND CODE

CIP Code	Grouping	Industry	
1	Agriculture	Agriculture, forestry, animal husbandry & fishery	AGR
2	Energy	Coal mining	CLM
3	Energy	Oil & gas excavation	PTM
4	C&P	Metal mining	MEM
5	C&P	Non-metallic minerals mining	NMM
6	Finished	Food and kindred products	F&B
7	Finished	Tobacco products	TBC
8	C&P	Textile mill products	TEX
9	Finished	Apparel and other textile products	WEA
10	Finished	Leather and leather products	LEA
11	SF&F	Saw mill products, furniture, fixtures	W&F
12	C&P	Paper products, printing & publishing	P&P
13	Energy	Petroleum and coal products	PET
14	C&P	Chemicals and allied products	CHE
15	SF&F	Rubber and plastics products	R&P
16	C&P	Stone, clay, and glass products	BUI
17	C&P	Primary & fabricated metal industries	MET
18	SF&F	Metal products (excluding rolling products)	MEP
19	Semi-finished	Industrial machinery and equipment	MCH
20	SF&F	Electric equipment	ELE
21	SF&F	Electronic and telecommunication equipment	ICT
22	SF&F	Instruments and office equipment	INS
23	Finished	Motor vehicles & other transportation equipment	TRS
24	Finished	Miscellaneous manufacturing industries	OTH
25	Energy	Power, steam, gas and tap water supply	UTL
26	Construction	Construction	CON
27	Services II	Wholesale and retail trades	SAL
28	Services II	Hotels and restaurants	HOT
29	Services I	Transport, storage & post services	T&S
30	Services I	Telecommunication & post	P&T
31	Services I	Financial Intermediations	FIN
32	Services II	Real estate services	REA
33	Services II	Leasing, technical, science & business services	BUS
34	Services III	Public administration and defense	ADM
35	Services III	Education services	EDU
36	Services III	Health and social security services	HEA
37	Services II	Other services	SER

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