Losing Steam? - An Industry Origin Analysis of China's Productivity Slowdown

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LOSING STEAM?
—AN INDUSTRY ORIGIN ANALYSIS OF CHINA'S PRODUCTIVITY SLOWDOWN

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ABSTRACT

Using the newly revised and updated CIP/China KLEMS data set, we conduct a full-fledged TFP scrutiny in a growth accounting framework *à la* Jorgenson (2001) to investigate the industry origin of total factor productivity (TFP) slowdown in China after a considerable productivity rise associated with reforms in the 1980s. We pay particular attention to the impacts of state-owned enterprise (SOE) reforms in the 1990s, China's participation in the World Trade Organization (WTO) in 2001, and the Global Finical Crisis (GFC) in 2008-2009 and the roles of individual industries and resources reallocation across industries in the Chinese economy. Our empirical results confirm that China's aggregate TFP growth indeed began to slow down in the early 1990s and decelerated further following China's WTO entry. However, it turned significantly negative in the wake of the GFC and had followed a productivity-deteriorating path ever since. Alertly, in the recent period 2012-2016 when the whole economy became increasingly less responsive to the government stimuli, industries engaged in producing intermediate input materials appeared to be the best TFP performer in the economy, replacing those manufacturers close to the end market. The results also show that the effect of labor reallocation on the TFP growth remained significantly positive over the entire period, which compensated for the heavy TFP loss caused by the industries prone to more government interventions and the misallocation of capital since the 1990s.

Keywords: Aggregate production possibility frontier (APPF); Domar aggregation scheme; total factor productivity (TFP); resource reallocation.

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

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1. INTRODUCTION

China's considerable slowdown in GDP following the Global Financial Crisis (GFC) in 2008-2009 has heated up the long debate about the sustainability of the China model of growth. Despite the government's unprecedented stimuli, the official statistics, though often critically questioned for exaggerating the real growth performance especially at the time of crisis (Wu 2014a; Maddison and Wu 2008), show that China has more than halved its GDP growth pace from an annual average of 13.5 percent over the period 2005-2007, or its post-WTO (World Trade Organization) heyday, to 6.5 percent during the period 2015-2017 (NBS, 2017: xx). While economists have been divided about the nature of the slowdown and the best choice of macroeconomic policy (Wu 2016a), one issue is not so much controversial, that is, to achieve a sustainable growth China needs to shift from an input- or physical capital-driven to a more productivity-led growth.

Indeed, such a substantive steam loss in the Chinese growth engine should have been picked up by the productivity performance of the economy long before the GFC shock. Unfortunately, empirical studies that use various parametric approaches can only provide us with estimates of the potential growth of productivity for certain (long-enough) period, subject to some imposed functional form. On the other hand, the majority of the empirical studies that apply the index number or non-parametric growth accounting approach have long been following an aggregate production function (APF) tradition with rather stringent assumptions that for all (underlying) industries "value-added functions exist and are identical across industries up to a scalar multiple" and "the aggregation of heterogeneous types of capital and labor must receive the same price in each industry" (Jorgenson, Ho and Stiroh 2005a: 364-365). Obviously, with the existence of heavy government interventions and institutional deficiencies that cause market imperfections in China, this APF approach is also inappropriate.

Frankly, we have not learnt much from the vast literature over the past two decades on China's post-reform TFP performance. Studies following the APF tradition tend to give distinctly different estimates of China's TFP growth for the same or similar periods.[1] For example, for the early reform period from the end of the 1970s to the early/mid 1990s, the estimated TFP growth rates range from between 1 and 1.5 percent per annum (Woo 1998; Young 2003) to around 4 percent per annum (Borensztein and Ostry 1996; Hu and Khan 1997; Fan et al. 1999). There is also no agreement about the trend of China's TFP growth. According to Perkins and Rawski (2008), over their five subperiods examined, China's TFP growth peaked in 1990-1995 at 6.7 percent per annum and then declined to 3.2 percent in 1995-2000 and 3.1 percent in 2000-2005. A study by Brandt and Zhu (2010), however, shows an opposite direction, in which China's TFP rose from 3.1 percent per annum in 1988-1998 to 4.3 percent in 1998-2007.[2]

To relax the stringent assumptions adopted in the APF tradition, one has to overcome severe data obstacles and integrate segmented and incomplete industry accounts into a consistent framework corresponding to the national accounts as elaborated in Jorgenson and Stiroh (2000). Ren and Sun (2005) made perhaps the first attempt to apply this approach to China. According to

[1] See Yanrui Wu (2011) for a substantive review and a statistical assessment.

[2] It may be necessary to cite Wu (2014) with more detailed time-variant results. (All notes in blue are the author's self reminders for the next revision.)

their preliminary estimates, China achieved a high TFP growth at 3.2 percent per annum for the period 1981-2000. But it experienced a substantial TFP slowdown from 6.5 percent in 1981-1984 to merely 0.5 percent per annum in 1994-2000. The Ren-Sun data was later significantly revised after the authors teamed up with other researchers including Dale Jorgenson. As reported in Cao *et al* (2009), their new estimates after the revision suggest a much slower annual TFP growth rate at 2.5 percent for the same period but a much more deceleration over the entire period from an astonishing height of 9.1 percent per annum in 1982-1984 to an absolute decline by 0.3 percent per annum in 1994-2000. They also show that the reallocation of capital in the early 1980s greatly enhanced the TFP growth but it turned negative in 1994-2000. The reallocation of labor had little impact throughout the entire period.

After a series of data efforts, initiated and conducted by Wu and his associates since the early 2000s,[3] Wu (2016a[4]) obtained his preliminary estimates using the Jorgenson model. He shows that China's average TFP growth over the post-reform period 1980-2010 was only 1.24 percent per annum, much slower than Cao *et al* (2009) and most of the other existing studies. Notably, this study for the first time in the growth accounting literature covers both China's post-WTO period and the early GFC period. Wu finds that following the WTO entry China's TFP performance did not improve but slowed down. China's aggregate TFP grew by 1.57 percent per annum in 2001-2007 compared to 1.79 in 1991-2001. The slowdown is found attributable to both the productivity slowdown within industries and the misallocation of capital across industries. It suggests that the deceleration of the aggregate TFP could have been more severe if the reallocation of labor did not play a positive and sizable role. In the wake of the GFC shock, China's TFP growth has entered a negative zone and declined drastically by 1.8 percent per annum over the period 2007-2010.

To assess the sustainability of China's growth it is more important to correctly identify the period when China's TFP began a durable deceleration. To this end, the Jorgensonian approach as adopted in Cao *at el* (2009) and Wu (2016a) is more appropriate than the APF approach not only because it is theoretically and methodologically sounder, but also because it is able to provide time series estimates of TFP growth with industry origin. There are, however, two important issues in assessing the estimated TFP performance, with one related to the underlying institutions in which economic activities take place and the other related to data and measurement problems. In this paper, although we focus on a new empirical exercise with a revised data set to address the problem of China's productivity slowdown, to better interpret the empirical results it is necessary to comprehend China's institutional problems and their likely effects on TFP growth.

Taking into account the institutional effect is imperative especially for developing economies or transition economies undertaking market oriented reforms and exposed to the international market. Since the neoclassical concept of TFP is a costless gain in the real output (Hulten 2000), when data issues are properly handled or all inputs are properly measured (Jorgenson and

[3] See, for example, Wu and Yue (2003, 2010 and 2012) and Wu, Yue and Zhang (2015) on the construction of labor employment and compensation matrices, Wu and Xu (2002) and Wu (2008 and 2015) on the estimation of capital stock and input, and Wu and Ito (2015) on the construction of input-output accounts time series and price matrices.

[4] Considering citing the preliminary extensions of this work in 2016a i.e. 2016b, 2016c, and 2016d…

Griliches 1967), TFP growth should mainly, if not only, capture or reflect the effect of positive externalities on GDP growth that are caused by institutional improvements alongside the development of such economies.[5] Yet, one should not simply ignore the effect of negative externalities that could take place at the same time due to improper policies and anti-reform interest groups. In most cases the estimated TFP growth should be a net effect of all the externalities, positive and negative, assuming that there is no major data or measurement problem. Therefore, in assessing the TFP estimates for China, we first need to understand the likely directions of the reforms, policy regime shifts, and institutional changes over different periods post reform.

After the *de facto* privatization in the farm sector and the earlier industrial reforms through a planning-market dual-track pricing scheme and a managerial responsibility system, as well as unprecedented opening up to foreign trade and direct investment in the 1980s, the 1990s began with Deng's call for bolder reforms in 1992 to break the political deadlock as the aftermath of the Tiananmen Event. Deng's push eventually induced the Politburo's decision to adopt the "socialist market economy" in 1993 and undertake state-owned enterprise (SOE) reforms in 1995. This ambitious reform process was interrupted by the Asian Financial Crisis (AFC) in 1997-1998. China's accession to the WTO in 2001 timely rejuvenated the debt and overcapacity-burdened and deflation-pressured economy and began a new wave of foreign trade and direct investment till the GFC shock in 2008. The post-GFC period is well observed as one in which the government has been struggling to maintain the pace of the growth while dealing with rising social, political and environmental problems that were long disguised by the superfast growth following the WTO.

In an economically decentralized authoritarian regime that is assigned by a highly centralized politically totalitarian regime (Xu 2011 and 2015),[6] all reforms are intended to achieve economic targets that are inevitably politicized. As such, all reforms are subject to political constraints and could create mixed externalities, positive as well as negative especially when the market forces are considered threatening the state power. For examples, the adopted "market system" has to be ensured "socialist" and the "liberalization of small SOEs" is to consolidate large-sized or "strategically important" SOEs. Participating WTO is expected to enhance rather than weaken the development of pro-market institution and thus promoting the growth of TFP. But the government may overreact to the potential international competition as presumed by the WTO rules by various interferences that distort the competitive allocation of resources. The authoritarian developmentalism only promotes the market when it seems to better serve the government's objectives. (My conjecture is that this will inevitably drive TFP to decline as income rises and the room for growth becomes smaller, given technology – need more logical deduction.)

[5] This is similar to Charles Hulten's idea that as long as we accept an aggregate production function with a Hick's neutral shift parameter and constant returns to scale, TFP growth does not capture technical change but managerial and organizational gains due to the technological advancement of an economy (Hulten 2000). This will be further discussed when finalizing the paper. …also Jorgenson and Griliches (1967) on the disappearance of TFP if "all inputs could be properly measured", and … yet restless institutional changes with mixed directions often observed in developing and transition economies cause externalities that cannot be easily measured as proper "input".

[6] Need to elaborate the regional decentralized authoritarian regime (Xu 20111 and 2015).

Using the newly revised and updated CIP/China KLEMS data set, we adopt a full-fledged KLEMS[7] accounting framework *à la* Jorgenson (2001) to investigate the industry origin of total factor productivity (TFP) slowdown in China after a considerable productivity alongside the initial reforms in the 1980s. We pay particular attention to the impacts SOE reforms in the 1990s, China's participation in the WTO in 2001 and the GFC in 2008-2009 and the roles of individual industries and resources reallocation across industries in the Chinese economy.

The rest of the paper is organized as follows. Section 2 introduces the Jorgensonian approach to accounting for the industry origin of the aggregate growth and productivity performance. Section 3 explains the new endeavor to improve the CIP/China KLEMS database. Section 4 presents our industry grouping strategy to distinguish economic activities by industries' "distance" from the market to reflect the level of government intervention, and periodization to reflect policy regime shifts. Section 5 presents and discusses the results. Finally, Section 6 concludes this study.

2. Accounting for Industry Origin of TFP

The widely used aggregate production function approach to TFP analysis is implicitly subject to very stringent assumptions that for all (underlying) industries "value-added functions exist and are identical across industries up to a scalar multiple" and "the aggregation of heterogeneous types of capital and labor must receive the same price in each industry" (Jorgenson, Ho and Stiroh 2005a). Given heavy government interventions and institutional set-ups that cause market imperfections in China, this approach is inappropriate for the growth accounting exercise of the Chinese economy. This study adopts Jorgenson's aggregate production possibility frontier (APPF) framework instead, incorporating Domar weights to account for contributions of individual industries to the growth of aggregate inputs and output.

The APPF approach in growth accounting relaxes the strong assumption that all industries are subject to the same value-added production function to account for the industry origin of aggregate growth (Jorgenson 1966). The Domar-weighted aggregation was introduced into the APPF framework in Jorgenson, Gollop and Fraumeni (1987) to exercise direct aggregation across industries to account for the role of American industries in the changes of aggregate inputs. It has been used in Jorgenson and Stiroh (2000), Jorgenson (2001) and Jorgenson, Ho and Stiroh (2005a, 2005b) to quantify the role of information technology (IT)-producing and IT-using industries in the US economy.

To illustrate this methodology, let us begin with a production function where industry gross output is a function of capital, labour, intermediate inputs and technology indexed by time. We use individual industries as building blocks which allow us to explicitly trace the sources of the aggregate productivity growth and input accumulation to the underlying industries. Focusing on an industry-level production function given by equation (1), each industry, indexed by *j*, purchases distinct intermediate inputs, capital and labour services to produce a set of products:

$$Y_j = f_j(K_j, L_j, X_j, T) \tag{1}$$

[7] KLEMS is an acronym for k(c)apital and labor as primary inputs, and energy, materials and services and intermediate inputs (O'Mahony and Timmer 2009).

where Y is output, K is an index of capital service flows, L is an index of labour service flows and X is an index of intermediate inputs (energy, materials and services), purchased from domestic industries and/or imported. Note that all input variables are indexed by time but this is suppressed for notational convenience.

Under the assumptions of competitive factor markets, full input utilization and constant returns to scale, the growth of output can be expressed as the cost-weighted growth of inputs and technological change, using the translog functional form:

(2) $$\Delta \ln Y_j = \bar{v}_j^K \Delta \ln K_j + \bar{v}_{jt}^L \Delta \ln L_j + \bar{v}_j^X \Delta \ln X_j + v_j^T$$

where $\bar{v}_j^K$, $\bar{v}_j^L$ and $\bar{v}_j^X$ are two-period averages of nominal weights of input $v_j^K = \frac{P_j^K K_j}{P_j^Y Y_j}$, $v_j^L = \frac{P_j^L L_j}{P_j^Y Y_j}$ and $v_j^M = \frac{P_j^X X_j}{P_j^Y Y_j}$, respectively. Note that under constant returns to scale $v_j^K + v_j^L + v_j^X = 1$, which is controlled by industry production accounts in nominal terms. Each element in the right-hand side of equation (2) indicates the proportion of output growth accounted for respectively by the growth of capital services ($\bar{v}_j^K \Delta \ln K_j$), labour services ($\bar{v}_j^L \Delta \ln L_j$), intermediate materials ($\bar{v}_j^X \Delta \ln X_j$) and total factor productivity (v_j^T).

One of the advantages of equation (2) is that it can better account for each input services by different types. For example, it can account for labor services provided by different types of labor with specific demographic, educational and industrial attributes, as shown in pioneering studies by Griliches (1960), Denison (1962) and Jorgenson and Griliches (1967). It has relaxed the usual strong assumption that treats numbers employed or hours worked as a homogenous measure of labor input. The growth of total labor input is thus defined as a Törnqvist quantity index of individual labour types as follows:

(3a) $$\Delta \ln L_j = \sum_h \bar{v}_{h,j} \Delta \ln H_{h,j}$$

where $\Delta \ln H_{h,j}$ indicates the growth of hours worked by each labour type h (with specific gender, age and educational attainment) and its cost weights $\bar{v}_{h,j}$ given by two-period average shares of each type in the nominal value of labour compensation controlled by the labor income of industry production accounts.

The same user-cost approach is also applied to K and X to account for the contribution of different types of capital asset (Z_k) and intermediate input (X_x) in production with type-specific, two-period average cost weight defined as $\bar{v}_{k,j}$ and $\bar{v}_{x,j}$, respectively:

(3b) $$\Delta \ln K_j = \sum_k \bar{v}_{k,j} \Delta \ln Z_{k,j} \text{, and}$$

(3c) $$\Delta \ln X_j = \sum_x \bar{v}_{x,j} \Delta \ln X_{x,j}$$

It should be noted that the equations from (2) through the whole set of (3) also explicitly express the methodological framework for the CIP industry-level data construction that is linked to and controlled by the national production and income accounts. This point will be discussed again when we discuss the data issues in the following section.

Using the value-added concept, equation (2) can be rewritten as:

(4) $$\Delta \ln Y_j = \bar{v}_j^V \Delta \ln V_j + \bar{v}_j^X \Delta \ln X_j$$

where V_j is the real value-added in j and v_j^V is the nominal share of value-added in industry gross output.

By rearranging equations (2) and (4), we can obtain an expression for the sources of industry value-added growth (i.e. measured in terms of input contributions):

(5) $$\Delta \ln V_j = \frac{\bar{v}_j^K}{\bar{v}_j^V} \Delta \ln K_j + \frac{\bar{v}_j^L}{\bar{v}_j^V} \Delta \ln L_j + \frac{1}{\bar{v}_j^V} v_j^T$$

Growth of aggregate value-added by the APPF approach is expressed as weighted industry value-added in a Törnqvist index:

(6) $$\Delta \ln V = \sum_j \bar{w}_j \Delta \ln V_j$$

where w_j is the share of industry value-added in aggregate value-added. By combining equations (5) and (6), we can have a new expression of aggregate value-added growth by weighted contribution of industry capital growth, industry labor growth and TFP growth:

(7) $$\Delta \ln V \equiv \sum_j \bar{w}_j \Delta \ln V_j = \sum_j \left(\bar{w}_j \frac{\bar{v}_j^K}{\bar{v}_j^V} \Delta \ln K_j + \bar{w}_j \frac{\bar{v}_j^L}{\bar{v}_j^V} \Delta \ln L_j + \bar{w}_j \frac{1}{\bar{v}_j^V} v_j^T \right)$$

Through this new expression, we have introduced the well-known Domar weights in our aggregation (Domar 1961), i.e. a ratio of each industry's share in total value-added (w_j) to the proportion of the industry's value-added in its gross output (v_j^V).

If we maintain the stringent assumption that capital and labour inputs have the same marginal productivity in all industries we can define aggregate TFP growth as:

(8) $$v^T \equiv \sum_j \bar{w}_j \Delta \ln V_j - \bar{v}^K \Delta \ln K - \bar{v}^L \Delta \ln L$$

However, this assumption is not likely to hold, in particular in China, as argued above. It is therefore interesting to look at the difference of the two measurement approaches. By subtracting equation (7) from equation (8) and rearranging, we can show how the aggregate TFP growth relates to the sources of TFP growth at the industry level and to the effect of factor mobility across industries (Jorgenson, Ho and Stiroh 2005a):

(9)

$$\begin{aligned} v^T = & \left(\sum_j \frac{\overline{w}_j}{\overline{v}_j^V} v_j^T \right) \\ & + \left(\sum_j \overline{w}_j \frac{\overline{v}_j^K}{\overline{v}_j^V} \Delta \ln K_j - \overline{v}_K \Delta \ln K \right) \\ & + \left(\sum_j \overline{w}_j \frac{\overline{v}_j^L}{\overline{v}_j^V} \Delta \ln L_j - \overline{v}_L \Delta \ln L \right) \end{aligned}$$

in which the *reallocation* terms in the second and third brackets can be simplified as:

(9')

$$v^T = \sum_j \frac{\overline{w}_j}{\overline{v}_j^V} v_j^T + \rho^K + \rho^L$$

Equation (9) expresses the aggregate TFP growth in terms of three sources: Domar-weighted industry TFP growth, reallocation of capital and reallocation of labor across industries. This Domar weighting scheme ($\overline{w}_j / \overline{v}_j^V$), originated by Domar (1961), plays a key role in the direct aggregation across industries under the Jorgensonian growth accounting framework. A direct consequence of the Domar-aggregation is that the weights do not sum to unity, implying that aggregate productivity growth amounts to more than the weighted average of industry-level productivity growth (or less, if negative). This reflects the fact that productivity change in the production of *intermediate inputs* do not only have an "own" effect but in addition they lead to reduced or increased prices in downstream industries, and that effect accumulates through vertical links. As elaborated by Hulten (1978), the Domar aggregation establishes a consistent link between the industry level productivity growth and the aggregate productivity growth. Productivity gains of the aggregate economy may exceed the average productivity gains across industries because flows of intermediate inputs between industries contribute to aggregate productivity by allowing productivity gains in successive industries to augment one another. The same logic can explain productivity losses.

The next two terms reflect the impact on aggregate TFP growth of the reallocation effect of capital (ρ^K) and labor (ρ^L) across industries, respectively. Each of the reallocation term is obtained by subtracting cost-weighted aggregate factor (capital or labor) input growth from the Domar-weighted input growth across industries. It should be noted that both theoretically and methodologically, when these terms are not negligible, it indicates that industries do not face the same factor costs, which suggests a violation of the assumption of the widely used aggregate approach. However, one should not expect a significant reallocation effect in an economy where there is a well developed market system. This is a very useful analytical tool for the Chinese case where strong government interventions in resource allocation may have caused severe market distortions.

3. DATA ISSUES

This part will be rewritten to emphasize the revision of the data.

The new data set is benefitted from the recently available China 2012 full scale input-output accounts as well as its 2015 extension. It also includes a revision of cross-industry price matrix and a new estimation of industry-level hours worked over time.

This study has uniquely benefited from a newly constructed economy-wide, industry-level data set in the on-going CIP/China KLEMS Project. It is beyond the scope of this study to go through a long history of various data studies that paved the way for this project.[8] We refer the interested reader to three working papers (Wu 2015; Wu and Ito 2015; Wu, Yue and Zhang 2015).

In the CIP Project the principles of industry data construction adhere to the underlying theory and data constraints as expressed in equation (2) and the set of equations (3a, 3b and 3c). This implies that the industry-level data are linked to and made consistent with the national production and income accounts of China.

Some features of the CIP data should be noted. 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). The reconstruction of the Chinese national accounts is based on different versions of official national accounts compiled under the Material Product System (MPS) prior to 1992 and the United Nations System of National Accounts (SNA) afterwards. China's SNA input-output accounts that are available for every five years since 1987 and a MPS input-output table for 1981 that is converted to a SNA-type table, are used to construct a time series of Chinese input-output accounts for the period 1981-2010 (Wu and Ito 2015). It should be noted that in constructing industry accounts we do not, or are not able to, challenge the official national accounts data except for consistency adjustment. Nonetheless, the widely discussed data problems observed at macro or aggregate level should be born in mind when interpreting our industry-weighted results for the aggregations.[9]

[8] 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.

[9] China's official estimates of GDP growth have long been challenged for upward bias (see Wu 2013 and 2014a for reviews). Alternative estimates have indeed shown slower growth rates than the official estimates, which inevitably also have level effects. The most affected sectors are identified as manufacturing and so-called "non-material services" (including non-market services). Wu (2013) shows that the official industrial output index has substantially moderated the impact of all external shocks. Besides, Wu (2014a) also shows that the 5-6 percent annual growth of labor productivity in "non-material services" based on official data appears to be too fast to be true

The nominal accounts are deflated by industry-level producer price index (PPI), constructed using official PPIs for the agricultural and industrial sectors and consumer price index (CPI) or its components for service industries (Wu and Ito 2015). However, the work reported in this chapter still uses the single deflation approach assuming changes in input prices are the same as changes in output prices, similar to the Chinese national accounts, rather than the double-deflation approach which would be preferred, due to lack of price data.[10] (Rewriting on double deflation)

For the required labor data, following earlier studies by Wu and Yue (2003, 2010 and 2012) which analyzed the industrial sector only, CIP has established economy-wide employment series (in both numbers of workers employed and hours worked) and compensation matrices for 37 industries. Workers include both employees as well as self-employed workers (farming households and self-employed retailers and transporters), cross-classified by gender, seven age groups and five educational levels (see details in Wu, Yue and Zhang 2015). (Rewriting on hours worked and labor compensation highlighting the work on the new Chinese IO tables.)

The construction of net capital stock at the industry-level proved most challenging. CIP has reconstructed annual flows of investment for the industrial sectors using official gross capital stock data at historical costs. But it has to adopt the official investment series estimates for the non-industrial sectors. The results are yet to be reconciled with the national accounts gross fixed capital formation data. Industry-specific investment deflators are constructed using the PPIs of investment goods industries and nominal wage index of construction workers (Wu 2008 and 2015). The industry-specific depreciation rates are estimated based on asset service lives and declining balance values used in the US national accounts, following the approach developed by Hulten and Wykoff (1981).

4. Industry Grouping and Periodization

Industry grouping

To better investigate the TFP performance of industries we categorize the 37 industries in the CIP database into eight groups (see Table A1), guided by the degrees of government intervention, either directly or indirectly. We first divide 24 industries of the industrial sector into three groups, namely "energy" including coal mining, petroleum and utilities, "commodities and primary input materials (C&P)" such as basic metals, chemicals and building materials, and "semi-finished and finished goods (SF&F)" such as wearing apparel, electrical equipment and machinery. "C&P" and "SF&F" in particular have been the key drivers of China's post-reform growth. According to their "distances" from the final demand, the "energy" group is located upstream, followed by "C&P" and "SF&F" being the closest to the final consumer market. The "SF&F" group will thus as conjectured be most inclined to indirect effects of government interventions in addition to any direct effect.

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if considering the international norm in history between -1 and +1 percent per annum (Griliches 1992; van Ark 1996).

[10] See Wu and Ito (2015) for very preliminary growth estimates at industry level using the double deflation approach although our work on prices is still on-going.

The non-industrial sectors are divided into five groups though their "location" of the production chain cannot be easily defined. Agricultural sector not only serves the final demand but also provides intermediate inputs to food processing and manufacturing industries and as such can be an important channel for indirect policies. Construction also delivers both investment and consumer goods. Services are divided into three groups with Services I consisting of state-monopolized services of important intermediate input industries such as financial intermediaries, transportation, and telecommunication services; Services II covering the rest of market services which are mainly final demand providers; and Services III denoted by "non-market services" including government administration, education and healthcare.

Taking the three industrial groups as examples, the "energy" group is monopolized, if not completely owned, by large, central government-owned enterprises due to its "strategic importance". It can easily access public resources but subject to strong administrative interferences. The "C&P" group is also considered important for downstream industries and hence heavily influenced though not completely owned by the government. Finally, the "SF&F" group consists of all downstream industries including not only private enterprises and foreign invested enterprises, but also state-owned enterprises particularly in heavy machinery industries. However, its competitive nature makes it difficult for the government to directly interfere in business decisions. On average, "SF&F" is more labor-intensive than the other groups, hence more in line with China's comparative advantage. Therefore, we may conjecture that the productivity growth of "SF&F" is faster than that of "energy" and "C&P".

Periodization

To better examine the productivity impact of major policy regime shifts on the Chinese economy, we divide the entire period 1980-2016 into five sub-periods, namely 1980-1991, 1991-2001, 2001-2007, 2007-2012 and 2012-2016. In most cases, the empirical findings are reported in line with this periodization.

The first sub-period 1980-1991 is characterized by decollectivization in agriculture and planning-market double track price reform with more operational autonomy in the industrial sector. It ended with rising inflation that triggered the 1989 Tiananmen political turmoil.

The second sub-period 1992-2001 began with Deng's call for bolder and deeper reforms in 1992 and the official adoption of the so-called "socialist market economy" in 1993. Wider opening-up to western technology and FDI drove a new wave of investment in export-oriented manufacturing capacities. Meanwhile, due to deregulations of private activities, new private firms absorbed a huge number of the state industrial employees who lost their jobs in the state-owned enterprise reforms of the 1990s. However, it also resulted in serious overinvestment. The Asian Financial Crisis (1997-1998) hit the Chinese economy hard, and from 1998 China entered a four-year-long (check) deflation period.[11]

[11] China's retail price index (RPI) declined from 380.8 in 1997 (1978=100) to 346.7 in 2003 and meanwhile producer price index (PPI) declined from 315.0 to 299.3 (NBS 2014, p.123). (discuss more about implications for the effect of double deflation?)

The third sub-period 2002-2007 began with China's WTO entry at the end of 2001. It is characterized by counteracting forces. On one hand, WTO-entry induced a further opening up to foreign trade and direct investment, and directed the Chinese economy further towards the market system. On the other hand, consolidated and enlarged state corporations resurged in the name of protecting national interests in a time of accelerating globalization. Meanwhile, growth-motivated local governments were pressured to race for rapid urbanization and heavy industrialization.

Finally, we divide the post-GFC period into two subperiods, i.e. the early post GFC period 2007-2012 and the late post-GFC period 2012-2016 to examine changed in China's growth and productivity performance alongside government policy changes aiming to moderate the impact of the global financial crisis and to explore new growth path. We would like to see how the unprecedented fiscal stimulus package from both the central and local governments affected the performance of different industries. (Need more on the government policy to reduce surplus production capacity and the impact of the so-called "supply-side" reform)

5. Empirical Results

Sources of China's growth in the APPF framework

We are now ready to examine China's aggregate GDP and TFP performance in the APPF framework. The results are summarized in Table 1 with industry and factor contributions to the real output growth. According to our estimates, the Chinese economy achieved a real output growth of 8.53 percent per annum in 1980-2016. With a quick glance, we could see that the "semi-finished and finished" (SF&F) group contributed over one third of the real output growth, Services II (market) nearly 20 percent, and agriculture, the "commodities and primary materials" (C&P) group and Services I (state monopolies) together slightly over 40 percent.

The underlying structural changes in the output could also be reflected by changes in the weighted growth contribution of industries before and after the GFC. Prior to the GFC, over the three subperiods, 1980-1991, 1991-2001 and 2001-2007, the weighted contribution of the "SF&F" group remained more or less the same, or between 36 and 38 percent, whereas the contribution of the "C&P" and "energy" groups increased significantly from totally 13 to 20 percent, and the contribution of Services I and II even more substantially from 21 to 43 percent. On the other hand, the role of agriculture dropped dramatically from nearly 20 to merely less than 4 percent. The role of construction remained no change but the role of Services III (non-market) turned to substantially negative (typically the case if the price change of the output suppresses that of the inputs).

The estimates reported in Table 1 also suggest that the underlying structural changes in the output in the wake of the GFC are worth a particular attention. The most striking change seems to have taken place between the industries of the industrial sector. The weighted contribution of the "SF&F" group to the growth halved from 36.3 percent in 2001-2007 to 18.9 percent in 2012-2016, whereas the "energy" group rose from 5.2 to 9.6 percent, though with a retreat to 2.6 in the early post GFC period, and the "C&P" from 15.7 to 24.9 percent. While Services II remained almost the same between 26 and 28 percent, Services I jumped to 28.6 yet Services III continued its rapid downward move.

TABLE 1

INDUSTRY AND FACTOR CONTRIBUTIONS TO CHINA'S VALUE-ADDED GROWTH, 1980-2016

(Contributions are in percentage points)

	1980-91	1991-01	2001-07	2007-12	2012-16	*1980-2016*
			Industry contributions to value-added growth			
Value-added growth (APPF, %)	8.78	8.94	10.06	7.88	5.29	*8.53*
- *Agriculture*	1.73	1.31	0.37	0.20	0.19	*1.01*
- *Construction*	0.51	0.49	0.56	0.47	0.27	*0.48*
- *Energy*	0.03	0.08	0.52	0.20	0.51	*0.20*
- *C&P*	1.12	1.99	1.58	1.96	1.32	*1.58*
- *SF&F*	3.22	3.44	3.66	2.54	1.00	*3.01*
- *Services I*	0.94	0.43	1.72	1.48	1.52	*1.07*
- *Services II*	0.94	1.22	2.62	2.21	1.37	*1.52*
- *Services III*	0.30	-0.01	-0.96	-1.18	-0.87	*-0.33*
			Factor contributions to value-added growth			
Value-added growth (APPF, %)	8.78	8.94	10.06	7.88	5.29	*8.53*
- Capital input:	4.84	6.47	8.53	8.96	7.20	*6.74*
- Stock	4.91	6.58	8.57	8.95	7.13	*6.79*
- Capital quality (composition)	-0.08	-0.10	-0.05	0.01	0.07	*-0.05*
- Labor input:	1.41	1.31	0.65	0.56	0.45	*1.03*
- Hours	1.34	0.80	0.60	-0.62	0.18	*0.67*
- Labor quality (composition)	0.06	0.51	0.06	1.18	0.26	*0.36*
- Aggregate TFP	2.54	1.16	0.88	-1.64	-2.35	*0.76*

Source: Author's estimates.

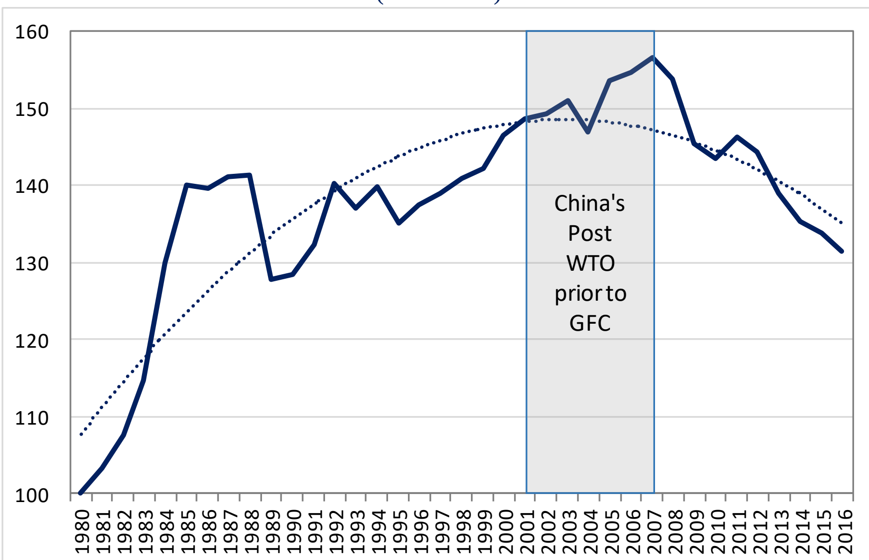
Our newly estimated aggregate TFP growth for China over the entire period 1980-2016 is 0.76 percent per annum. The TFP performance was highly unstable over time with its peak in the early reform period 1980-1991 at 2.54 percent per annum in comparison to its worst performance in the late post-GFC period 2012-2016 at -2.35 percent per annum. It appears that the deceleration began is indeed in the 1990s. In the post-WTO period, compared to the early reform period the growth momentum of TFP has already lost nearly two thirds from 2.54 to 0.88 percent per annum. The GFC drove the TFP growth into a rapid downturn from -1.64 percent in 2007-2012 to -2.35 percent per annum in 2012-2016.

If the annual aggregate TFP growth rates are translated into a level index with the initial point 1980 as the base year and equal to 100 as shown in Figure 1, we observe for the first time not only the changes of China's TFP from the early reform period to the current time, but more importantly a provoking underlying polynomial trend that highlights the potential TFP growth over different periods characterizing policy regime shifts.[12] The first TFP drive was clearly observed in the early 1980s associated with China's agricultural reform. As a result the Chinese productivity performance stayed well above the trend until its collapse following the 1989 political crisis. The TFP growth recovered in the early 1990s but only short-lived. Intuitively, the Tiananmen Democratic Movement in 1989 and the Asian Financial Crisis in 1997-1998 had a great TFP impact, but not sufficiently altered the underlying TFP trend. The TFP began to accelerate from 1995, yet it could only return to the trend by the time of China's WTO entry. China's post-WTO period, nonetheless, only observed the resurgence of a fast TFP growth in

[12] Need to discuss why this index appears to be distinctly different from those found in the earlier version of the exercise, highlighting the role of double deflation in the estimation of real value added.

2006-07 above the trend line before its sharp drop in the wake of the global financial crisis. The index suggests clearly that it is difficult to overcome the nearly decade-long TFP downturn unless the government is determined to seriously reform the economy and let the market to correct severe distortions in resource allocation and income distribution. Our new findings can confirm the finding in Wu (2006a) that China's accession to the World Trade Organization (WTO) was accompanied by a slowdown rather than an acceleration of TFP growth.

FIGURE 1
INDEX OF AGGREGATE TOTAL FACTOR PRODUCTIVITY IN CHINA
(1980 = 100)



Source: Constructed based on results shown in Table 1.

The contribution of factors in the lower panel of Table 1 may help explain why China lost its TFP strength so early in aggregate terms. Of the 8.53-percent annual output growth rate for the entire period under investigation, the contribution of capital input was 6.74 percentage points (ppts), labor input 1.03 ppts and TFP 0.76 ppts. This means that 79 percent of the real value-added growth relied on capital input growth, 12.1 percent on labor input growth, and 8.9 percent on the total factor productivity growth. The contribution of capital input growth increased from 55 percent in the 1980s to 84.7 percent post WTO, but to more than 100 percent in the wake of the global financial crisis, that is, 113.7 percent for the period 2007-2012 and 136 percent for the period 2012-2016. Overinvestment appears to be the key driver behind such a significant TFP slowdown. Obviously, the government's efforts to maintain growth through a large number of state infrastructural projects created negative externalities that were overwhelming and sacrificed efficiency considerably. On the other hand, the contribution of labor input declined from 16 percent in the 1980s to 6.5 percent post WTO. Following the GFC, nonetheless, this slightly reversed back to 7.2 percent in 2007-2012 and 8.4 percent in 2012-2016.

Sources of China's labor productivity growth

Table 2 presents the results of a decomposition of China's aggregate value-added per hour worked into changes in capital deepening, labour quality and TFP. This enables us to separate the contribution of natural hours worked from the contribution of genuine labour productivity improvement and its sources. On average, for the entire period 1980-2016 labor productivity growth contributed 83.8 percent of the real output growth of 8.53 percent per annum, or 7.15 percentage points (ppts), whereas the increase of hours worked contributed 16.2 percent, or 1.38 ppts. The early post-reform Chinese economy benefited significantly from the increase in hours worked or the so-called "demographic dividend". However, the contribution of the dividend to labor productivity declined rapidly from 32.4 percent in 1980-1991 to 12.9 percent in 2007-2012. It completely disappeared (-17.3 percent) in the early post-GFC period but came back with a much smaller role (7.3 percent) in the late post-GFC period.

TABLE 2
SOURCES OF CHINA'S LABOR PRODUCTIVITY GROWTH, 1980-2016
(Contributions are weighted growth in percent)

	1980-91	1991-01	2001-07	2007-12	2012-16	*1980-16*
Value-added growth (APPF, %)	8.78	8.94	10.06	7.88	5.29	*8.53*
- Hours	*2.84*	*1.60*	*1.30*	*-1.36*	*0.39*	*1.38*
- Labor productivity (VA/hour)	*5.94*	*7.35*	*8.77*	*9.24*	*4.90*	*7.15*
- Capital deepening	3.34	5.68	7.83	9.70	7.00	*6.03*
- Labor quality	0.06	0.51	0.06	1.18	0.26	*0.36*
- TFP	2.54	1.16	0.88	-1.64	-2.35	*0.76*

Source: Author's estimates.

The growth of China's labor productivity accelerated till the early post-GFC period from 5.94 percent per annum to 9.24 percent per annum. However, it lost the momentum during the late post-GFC period and dropped to 4.9 percent per annum. Capital deepening played an increasing role in driving the labor productivity growth. Its contribution rose significantly from 56.2 percent in 1980-1991 to 89.3 percent in 2001-2007 and further to 142.6 percent in the late post-GFC period, suggesting that there must have existed a serious, decade-long disequilibrium in the economy caused by the misallocation of resources.[13]

The industry origin of aggregate TFP growth

In order to explicitly account for differences across industries in their impact on China's aggregate TFP performance we introduce the Domar weights in the exercise, following the studies on the US economy by Jorgenson, Ho and Stiroh (2005a and 2005b). The TFP growth rates presented in the first line of Table 3 are estimated with the stringent assumption that marginal productivities of capital and labour are the same across all industries, which are the same as those presented in Table 1 and Table 2. As expressed in equation (9), using the Domar weights the aggregate TFP growth rate can be decomposed into three additive components, i.e. 1) the change of the Domar-weighted aggregate TFP; 2) the change of capital reallocation effect; and 3) the change of labor reallocation effect.

As Table 3 shows, on average of the entire period 1980-2016, China's TFP growth that could be attributed to industries as estimated with the Domar weights is merely 0.30 percent per annum,

[13] Consider a comparison of results in Tables 1 and 2 with the earlier estimates that did not use double deflation and the explicit KLEMS framework.

much slower than the aggregate TFP growth of 0.76. This implies a net factor reallocation effect of 0.46 ppts that will be discussed later.

The performances of industry groups are distinctly different, which suggests that treating individual industries homogenous in growth accounting as in the AFP tradition can be misleading. There are only three groups that played a positive role, i.e. the "SF&F" group (1.26 ppts), agriculture (0.62 ppts) and the "C&P" group (0.46 ppts). However, three loss-making groups, namely the "energy" group (-0.47 ppts), Services II (-0.65 ppts) and Services III (-0.88 ppts) eroded 85 percent their TFP gain. Such a sharp contrast across industry groups in the Domar weighted TFP performance can also be observed over different sub-periods.

TABLE 3

DOMAR-WEIGHTED TFP GROWTH AND REALLOCATION EFFECT IN THE CHINESE ECONOMY

(Growth in percent per annum and contribution in percentage points)

	1980-91	1991-01	2001-07	2007-12	2012-16	*1980-16*
Aggregate TFP growth	2.54	1.16	0.88	-1.64	-2.35	*0.76*
1. Domar-weighted TFP growth	1.52	1.08	0.89	-2.34	-2.57	*0.30*
- Agriculture	*1.02*	*0.91*	*0.32*	*0.04*	*-0.07*	*0.62*
- Construction	*0.06*	*-0.07*	*0.20*	*-0.13*	*-0.20*	*-0.01*
- Energy	*-0.66*	*-0.49*	*-0.49*	*-0.53*	*0.18*	*-0.47*
- C&P	*-0.30*	*1.23*	*0.27*	*0.48*	*0.86*	*0.46*
- SF&F	*1.44*	*2.02*	*1.41*	*0.30*	*-0.12*	*1.26*
- Services I	*0.23*	*-1.03*	*0.67*	*0.39*	*0.22*	*-0.02*
- Services II	*-0.22*	*-0.98*	*0.29*	*-0.99*	*-2.00*	*-0.65*
- Services III	*-0.05*	*-0.51*	*-1.79*	*-1.91*	*-1.44*	*-0.88*
2. Reallocation of K (ρ^K)	0.46	-0.27	-1.10	-0.11	-0.26	*-0.16*
3. Reallocation of L (ρ^L)	0.56	0.34	1.10	0.81	0.47	*0.62*

Source: Author's estimates following equation (9).

A closer examination through sub-periods with the background of the policy regime shifts and groups exposed to different policy environments may shed important light on the role of the government and help explain the slowdown and decline of China's TFP growth.

The agricultural sector benefited most from reforms in the 1980s especially from the *de facto* privatization on farming and deregulations on rural township-village enterprises. It contributed significant 1.02 ppts to the Domar-weighted TFP growth at 1.52 percent per annum in 1980-1991 and 0.91 ppts to the Domar-weighted TFP growth at 1.08 percent per annum in 1991-2001. Even in the post-WTO period when the Domar-weighted TFP growth decelerated to 0.89 percent per annum, agriculture still contributed more than one third or 0.32 ppts. This is suggestive of a process in which the agricultural sector released capital (including land) and labour that had a marginal productivity below the sector's average. By shedding these "surplus" factors, the average productivity with which factors were used was still growing. But clearly this could not be a source of long-run growth. it is not a surprise to see its role disappearing in the recent decade.[14]

[14] Discuss more on why this finding is very different from that based on the single deflation approach, and why this makes a better sense.

Changes of their roles in the Domar-weighted TFP growth among the three industrial groups before and after the GFC, that is the "SF&F", "C&P" and "energy" groups, are worth a careful examination. Let's bear in mind that the "SF&F" group is assumed to be closest to the end market, hence subject to the least state interferes, the "energy" group is assumed to be furthest from the end market, hence subject to the strongest government control, whereas the "C&P" group stays in between. Before the GFC, Deng's reengineered reform though the implementation of the "socialist market economy" seems to be highly TFP promoting. The "SF&F" group as the most important productivity contributor from the early reform period was indeed enjoyed its heyday in the 1990s, contributing 2.02 ppts to the Domar-weighted TFP growth at 1.08 percent per annum. The best performance of the "C&P" group was also observed in the 1990s, contributing 1.23 ppts. However, the "energy" group shows little responsive to the reforms in the 1990s and appears to be a persistent productivity loser.

It is clear that the productivity slowdown of the "SF&F" and "C&P" groups plus the agriculture sector drove the Domar-weighted TFP slowdown along with China's accession to the WTO. Compared to the period 1991-2001 in group contribution in percentage points, the slowdown in 2001-2007 was 30, 78 and 64 percent respectively. This puzzling result may be somewhat supportive to the well observed increasing interventions by local governments since the 2000s aiming to promote local urbanization and heavy industrialization (Jinglian Wu 2008). Table 3 shows that while the contribution of the "SF&F" and "C&P" groups to the TFP growth considerably reduced, the contribution of construction and state monopolized services (Services I), i.e. transportation, telecommunication and financial services, increased from -0.07 to 0.20 ppts and from -1.03 to 0.67 ppts, respectively.

Yet, the GFC shock turned this pattern around completely. In the early post-GFC period, the "energy" group remained negative as before, but it turned positive surprisingly in the late post-GFC period. The role of the "C&P" increased with its contribution to the Domar-weighted TFP growth up from 0.27 ppts in 2001-2007 to 0.48 ppts in 2007-2012 and further to 0.86 ppts in 2012-2016. In contrast, the role of the "SF&F" group first experienced a substantial decline in the early post-GFC period and then became negative in the late post-GFC period. However, the most recent development shows that while the effect of the unprecedented government injection has quickly abated after 2012, there are increasing signs indicating that China's surplus capacity in manufacturing is worsening and may take many years to solve.

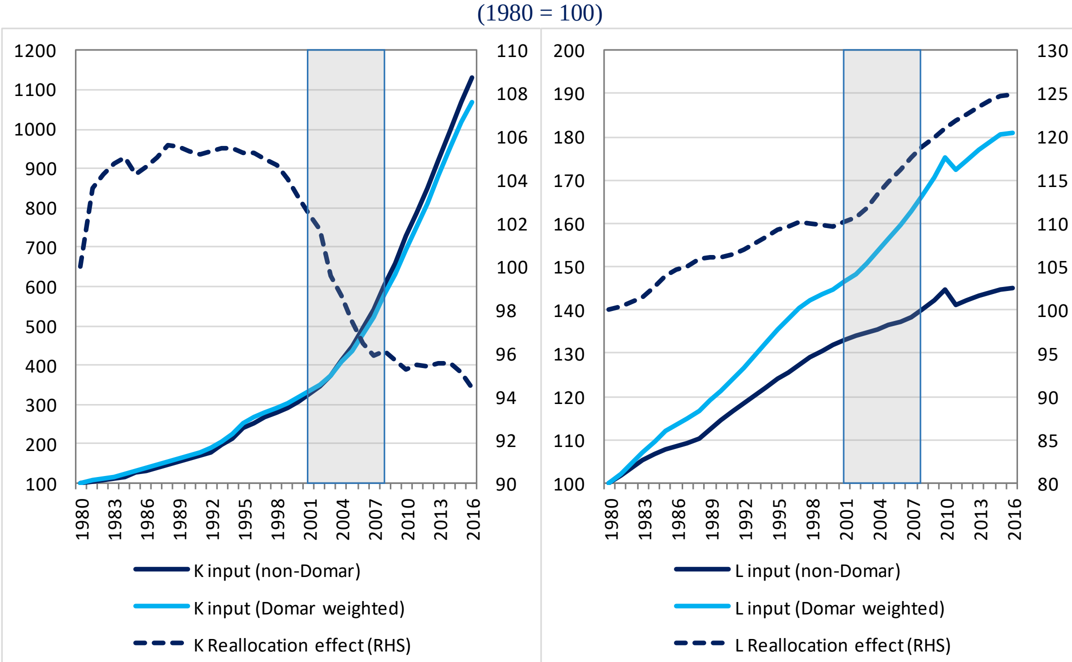
The effect of factor reallocation

The slower Domar-weighted TFP growth at 0.30 percent per annum compared to the aggregate TFP growth at 0.76 percent per annum implies that about 40 percent of the aggregate TFP growth is attributable to the productivity growth within individual industries while 60 percent to the reallocation of capital and labor across industries. Following equation (9), in the lowest panel of Table 3 we show that on average this effect consists of a positive labor reallocation effect (ρ^L) of 0.47 percentage points and a negative capital reallocation effect (ρ^K) of -0.22 percentage points. Figure 2 presents the index of each of these effects.

It should be noted that such a magnitude of reallocation effect is typically not observed in market economies. For example, based on their empirical work on the US economy in 1977-2000, Jorgenson, Ho and Stiroh (2005a) showed that first, the reallocation effect was generally negligible and second, if it was non-negligible for some sub-periods, the capital and labor reallocation effects generally moved in opposite directions. Jorgenson, Gollop and Fraumeni (1987) also reported the reallocation of capital that was typically positive and the reallocation of labor that was typically negative for the US economy for the period 1948-79. This is because capital grew more rapidly in industries with high capital service prices, hence high returns on capital, whereas labor grew relatively slowly in industries with high marginal compensation.

In the case of China, the much large magnitude and unexpected sign of capital and labor reallocation effects have two important implications. First, individual industries indeed face significantly different marginal factor productivities suggesting that there are barriers to factor mobility which cause misallocation of resources in the economy. The flip-side of this finding is that corrections to the distortions can potentially be productivity-enhancing, which might be good news in terms of much talked and long awaited structural reforms.

FIGURE 2
DOMAR AND NON-DOMAR WEIGHTED FACTOR INPUT INDICES AND REALLOCATION EFFECTS
(1980 = 100)



Source: Constructed based on results shown in Table 3.

We find that the effect of labor reallocation remained generally positive over time. This suggests that labor market was much less distorted than the capital market benefitting from increasing labor mobility along with reforms. Notably, the post-WTO period experienced the most significant gain from labor reallocation (1.10 ppts in 2001-07, the shaded area in Figure 2) which could be driven by the rapid expansion of export-oriented, labor-intensive industries that was in line with China's comparative advantage. The case of capital reallocation is different. The early reform period was the only period that saw a positive effect of capital reallocation (0.46 ppts in 1980-1991) due to partial removal of the distortions inherited from the central planning period. However, the effect turned into negative subsequently and substantially following China's WTO entry (-1.10 ppts in 2001-07, the shaded area in Figure 2). This is likely because of the enhanced role of the government that supported the state sector resurging in upstream industries. The so induced negative externalities could be over whelming and destructive. We argue that this could be the key factor that was behind China's productivity slowdown since the WTO entry. This has been no significant improvement ever since.

6. Concluding Remarks

Using the newly constructed CIP database, this study adopts the aggregate production possibility frontier approach in the Jorgensonian growth accounting framework incorporating the Domar aggregation approach to examine the sources of growth in the Chinese economy for the reform period 1980-2016. This approach provides a highly appropriate analytical tool for investigating the industry origin of aggregate productivity slowdown in the Chinese economy.

Our results show that China achieved a TFP growth of 0.76 percent per annum for the entire period 1980-2016. This means that compared to an industry-weighted value-added growth of 8.53 percent per annum, the TFP growth accounted for about 8.9 percent of the average GDP growth. This is a result that is much smaller than all previous productivity studies on the Chinese economy based on the aggregate production function approach, e.g. about 40 percent contribution estimated by Bosworth and Collins (2008) and by Perkins and Rawski (2008). However, compared to the only work in the literature that applied the same approach for the period 1982-2000 by Cao *et al.* (2009), our finding is about one third of their result of (2.51 percent per annum). The differences could come from data construction, measurement, classification and coverage (e.g. we have 11 service sectors whereas Cao *et al.* put all in one sector).

At the industry group level, as conjectured, we do find that, in general, industries less prone to government intervention, such as agriculture and the "semi-finished & finished" manufactures, tended to have higher total factor productive growth rates than those industries subject to direct government interventions, such as the "energy" group. The fact that the "SF&F" group maintained a positive TFP growth while the "energy" group experiencing persistently TFP decline suggests the existence of "cross-subsidization" between upstream and downstream industries in which the government plays different roles to serve its strategy. This is damaging to the overall economic environment affecting the TFP growth.

We also found strong effects of factor input reallocation across industries which significantly address the key issue of resource misallocation in the on-going policy debate. This large magnitude of the reallocation effect on the one hand reflects barriers to factor mobility in the economy and on the other hand also suggests potential gain from market-driven reallocation. Institutional deficiencies in the Chinese economy that allow the government at all levels to intervene resource allocation at their discretion are responsible for resource misallocation. We do not expect the TFP growth to turn positive before the government at all levels is disentangled from the business and the market is allowed to correct the cost structure of the business.

APPENDIX

TABLE A1

CIP/CHINA KLEMS INDUSTRIAL CLASSIFICATION AND CODE

CIP Code	EU-KLEMS Code	Grouping	Industry	
1	AtB	Agriculture	Agriculture, forestry, animal husbandry & fishery	AGR
2	10	Energy	Coal mining	CLM
3	11	Energy	Oil & gas excavation	PTM
4	13	C&P	Metal mining	MEM
5	14	C&P	Non-metallic minerals mining	NMM
6	15	Finished	Food and kindred products	F&B
7	16	Finished	Tobacco products	TBC
8	17	C&P	Textile mill products	TEX
9	18	Finished	Apparel and other textile products	WEA
10	19	Finished	Leather and leather products	LEA
11	20	SF&F	Saw mill products, furniture, fixtures	W&F
12	21t22	C&P	Paper products, printing & publishing	P&P
13	23	Energy	Petroleum and coal products	PET
14	24	C&P	Chemicals and allied products	CHE
15	25	SF&F	Rubber and plastics products	R&P
16	26	C&P	Stone, clay, and glass products	BUI
17	27t28	C&P	Primary & fabricated metal industries	MET
18	27t28	SF&F	Metal products (excluding rolling products)	MEP
19	29	Semi-finished	Industrial machinery and equipment	MCH
20	31	SF&F	Electric equipment	ELE
21	32	SF&F	Electronic and telecommunication equipment	ICT
22	30t33	SF&F	Instruments and office equipment	INS
23	34t35	Finished	Motor vehicles & other transportation equipment	TRS
24	36t37	Finished	Miscellaneous manufacturing industries	OTH
25	E	Energy	Power, steam, gas and tap water supply	UTL
26	F	Construction	Construction	CON
27	G	Services II	Wholesale and retail trades	SAL
28	H	Services II	Hotels and restaurants	HOT
29	I	Services I	Transport, storage & post services	T&S
30	71t74	Services I	Telecommunication & post	P&T
31	J	Services I	Financial Intermediations	FIN
32	K	Services II	Real estate services	REA
33	71t74	Services II	Leasing, technical, science & business services	BUS
34	L	Services III	Public administration and defense	ADM
35	M	Services III	Education services	EDU
36	N	Services III	Health and social security services	HEA
37	O&P	Services II	Other services	SER

Source: See the text.

Note: This is based on Wu's series of works to reclassify official statistics reported under different CSIC systems adopted in CSIC/1972, CSIC/1985 and CSIC/1994 (see Wu and Yue 2012; Wu and Ito 2015). The current Chinese classification system CSIC/2011largely conforms to the 2-digit level industries of the ISIC (Rev. 4) and can be reconciled with the EU-KLEMS system of classification (see Timmer et al., 2007).

TABLE A2

INDUSTRY CONTRIBUTIONS TO VALUE-ADDED AND TOTAL FACTOR PRODUCTIVITY GROWTH 1980-2016

	Value-Added			Total Factor Productivity		
	VA weight	VA growth	Contribution to aggregate VA growth	Domar weight	TFP growth	Contribution to aggregate TFP growth
AGR	0.183	4.69	1.01	0.299	1.74	0.62
CLM	0.016	5.61	0.08	0.031	0.41	0.00
PTM	0.016	-6.77	-0.12	0.025	-12.08	-0.30
MEM	0.006	10.22	0.06	0.014	1.38	0.02
NMM	0.006	9.39	0.05	0.013	1.79	0.02
F&B	0.027	12.50	0.33	0.127	0.56	0.06
TBC	0.011	8.20	0.09	0.017	-4.20	-0.09
TEX	0.024	10.92	0.28	0.106	0.97	0.08
WEA	0.009	13.55	0.12	0.034	0.89	0.03
LEA	0.004	12.07	0.05	0.019	0.50	0.01
W&F	0.007	13.02	0.10	0.026	1.02	0.03
P&P	0.011	11.98	0.13	0.038	1.06	0.04
PET	0.011	2.03	-0.01	0.045	-3.34	-0.13
CHE	0.035	15.30	0.54	0.136	1.77	0.23
R&P	0.011	17.86	0.21	0.048	2.27	0.10
BUI	0.024	10.57	0.26	0.077	0.70	0.08
MET	0.031	8.82	0.25	0.138	-0.28	-0.02
MEP	0.012	17.41	0.21	0.050	2.41	0.10
MCH	0.034	13.51	0.48	0.118	2.79	0.30
ELE	0.015	20.42	0.29	0.066	2.91	0.13
ICT	0.016	36.13	0.48	0.076	6.48	0.29
INS	0.003	12.84	0.05	0.011	2.28	0.02
TRS	0.019	18.85	0.35	0.077	2.79	0.18
OTH	0.015	16.44	0.26	0.044	0.30	0.09
UTL	0.026	8.14	0.25	0.104	-0.56	-0.03
CON	0.056	8.83	0.48	0.211	0.03	-0.01
SAL	0.079	9.41	0.69	0.138	0.27	-0.01
HOT	0.018	8.23	0.15	0.050	-1.48	-0.06
T&S	0.050	7.89	0.40	0.100	-0.93	-0.08
P&T	0.014	13.35	0.19	0.025	-0.98	0.03
FIN	0.051	10.87	0.48	0.074	2.02	0.03
REA	0.041	8.16	0.31	0.056	-7.15	-0.42
BUS	0.025	7.73	0.23	0.060	-1.39	-0.08
ADM	0.033	1.56	0.00	0.060	-4.42	-0.30
EDU	0.026	-6.14	-0.17	0.042	-7.41	-0.32
HEA	0.013	-10.27	-0.16	0.032	-6.79	-0.26
SER	0.020	5.08	0.15	0.040	-3.32	-0.07
Sum	*1.000*		*8.53*	*2.628*		*0.30*

Source: See Tables 1 and 3.

Notes: See Table A1 for industry abbreviation. Value added and TFP growth rates are annualized raw growth rates in percent. Industry contribution to VA and TFP growth is weighted growth rate in percentage points. See equation (9) for Domar aggregation.

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