

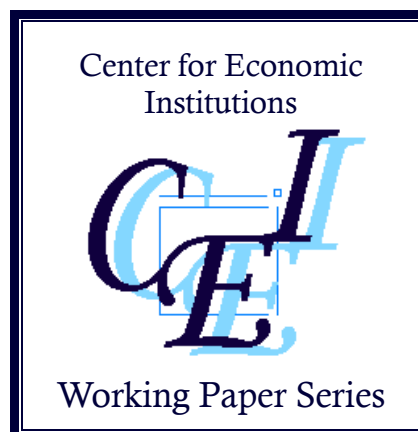
Center for Economic Institutions
Working Paper Series

No. 2019-4

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TFP Changes in China”**

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August, 2019



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TOWARDS AN INSTITUTIONAL INTERPRETATION OF TFP CHANGES IN CHINA

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ABSTRACT*

This research note reiterates the productivity theory in the Solow growth accounting framework to explore an institutional interpretation of changes in total factor productivity. In theory, total factor productivity or TFP growth is a costless gain in output, which captures the effect of positive externalities caused by spillovers of technological and organizational changes in a perfect market system. This provides a yardstick to gauge institutional effect on output in an imperfect market system if all inputs are properly measured. Using the Chinese case, I show that an integrated approach *a la* Jorgenson and Griliches (1967) that ensures a consistency between theory, methodology and measurement can facilitate empirical exercises even with data problems, and a so-constructed TFP index for China can satisfactorily reproduce China's post-reform productivity path with institutional interpretations.

Keywords: Total factor productivity (TFP) growth; Factor reallocation effect on TFP growth; Institution; Economic reform.

JEL Classification: C80, H70, O40, P30

* This article reports my work as a visiting professor at the Center for Economic Institutions (CEI) of IER, Hitotsubashi University from October 2018 to March 2019. It summarizes my long empirical pursuit to properly measure China's productivity performance at IER and my exploratory thinking of institutional implications of productivity change. I would like to thank seminar participants at CEI/IER, Hitotsubashi University for their interesting discussions. George G. Zhang, David T. Liang and Zhan Li provided excellent research assistance in updating the CIP (China Industry Productivity)/China KLEMS database. I would also like to thank CEI for generously hosting my research and the research supports from JSPS Research Grant No. 17K03678 and the RIETI Asian Industrial Productivity Program.

1. SETTING OFF THE QUEST

The “China model of growth”, propelled by the growth competition among regional governments motivated by political promotions (Li and Zhou, 2005; Zhou, 2007), was highly praised for having solved the essential incentive problems in an authoritarian regime with public ownership of land (Cheung, 2009). Nevertheless, the substantial and seemingly durable slowdown of the Chinese economy over the recent decade following the global financial crisis (2008-2009)¹ has caused a heated debate about the nature of the slowdown and a call for rethinking the role of the government.² While the debate remains inconclusive, the most recently observed aggressive advancement of state-owned (or connected) enterprises at the cost of the private sector has caused even more concerns (e.g. Johansson and Feng, 2016; Du, Liu and Zhou, 2014).³ These have regrettably clouded China’s fortieth anniversary of the reform initiated in 1978. At the time for China to have reached this chronological milestone, economists who have devoted most of their careers to the study of the Chinese economy unsurprisingly find themselves obligatory for a critical reassessment of China’s growth model. This is an irrefutable call.

There have been a large number of studies since the 1990s attempting to offer explanations either for the “China miracle” in terms of China’s successful escape from the heavy burden of the Maoist centrally-planned economy (Lin, Cai and Li, 1996) or for the “China puzzle” in terms of China’s rapid growth without essential pro-market institutions (Xu, 2011). We can broadly categorize these studies in two strands. The first strand examines the performance of the economy in an aggregate growth accounting framework that is subject to major neoclassical assumptions. The second strand attempts to explain China’s growth by institutional or political economy factors that are deemed imperative to motivate local governments and officials to compete for a faster growth. However, the two strands often find difficulties to reconcile their research findings. Some highly praised institutional reforms might have induced a rapid output growth, but not yet accompanied by an apparent improvement of productivity. It is not clear whether this is caused by data or measurement problems or by the fact that some seemingly growth-promoting reform or institutional change takes its toll on productivity.

Based on my elongated experiences in empirical research on measuring China’s sources of growth, this research note attempts to explore institutional interpretation of changes in total factor productivity (TFP) that can be derived from a Solow-type of growth accounting framework, well known as the “Solow residual”. I begin my quest with the ideas of those pioneers who discovered, explored and also critically questioned the “residual”, but focus on the TFP concept after it was explicitly integrated with the economic theory by Robert Solow in 1957. I then revisit the concept theoretically and methodologically with an attempt to understand its institutional implications. Next, with the institutional interpretation of the concept as a theoretical yardstick I abstractly explore the China model of growth focusing on

¹ The official statistics, though being critically questioned for exaggerating China’s real growth performance especially at the time of crisis (Maddison and Wu, 2008; Wu, 2014 and 2016a), suggests China to have more than halved its GDP growth pace from an annual average of 13.5 percent in its post WTO heyday of 2005-2007 to 6.5 percent in 2015-2017 (NBS, 2018: Table 3-4).

² Chinese economists have been divided about the nature of the slowdown from different perspectives ranging from the short-run to the long-run, from external to internal, or from structural to institutional problems. See Wu (2016a) for a critical review of the debate.

³ See also the most recent reports in *Economist* on July 20, 2017 and Hong Kong-based *South China Morning Post* on September 21, 2018.

its institutional effect on productivity. Lastly, I substantiate the quest with my most recent empirical results on China's TFP performance.

2. THE "RESIDUAL" AS A "MEASURE OF OUR IGNORANCE"

The efficiency index idea

According to Zvi Griliches (1996), Morris Copland might be the first one who proposed an output-over-total-input index to capture the "residual" in the real output to reflect efficiency improvement in an economy. Copland's idea appeared in 1937 and was further elaborated in Copland and Martin in 1938. The two authors suggested to first construct an input index for an economy constituting "the physical volume of wealth used in production" weighted by the total property income and "a correspondingly weighted man-hour series" (1938: 104). In their opinion, when a physical output index was compared to this input index, and if a divergence emerges from the movements of the two indices, that is, a deviation from the value of one, it would be "a rough measure of changes in the efficiency of our economic system" (1938: 132).

The Copland-Martin efficiency index could be easily expressed by the fundamental GDP accounting identity $p_t Q_t = w_t L_t + r_t K_t$. That is, the current value of the total output of the product market, $p_t Q_t$ (where p_t and Q_t stand for the market determined price and quantity, respectively), is equal to the current value of the total cost of the primary factors, $w_t L_t + r_t K_t$ (where L_t and K_t stand for labor and capital inputs, respectively, with w_t and r_t as their corresponding prices).

However, since economic well-being is based on the quantity of goods and services, not the amount spent on them, we need to hold all prices constant. To do so, we can simply use the prices of any base year to value current inputs and output. But, can we still maintain the accounting identity in real terms without revising the identity formula? The answer is yes only if there is no productivity change in any non-base year. To capture productivity changes over time, we can follow Charles Hulten (2001: 6) to establish a new accounting identity with a scaling factor, S_t , to bring the constant-price account into balance, that is, $p_0 Q_t = S_t (w_0 L_t + r_0 K_t)$. Obviously, if both sides of the identity are divided by $(w_0 L_t + r_0 K_t)$, the scaling factor, S_t , is the ratio of output per unit of total factor input.

The criticism

Milton Friedman and John Hicks were perhaps among the very few who paid close attention to the potential problems underlying such an efficiency index. Friedman interpreted the idea by Copland and Martin as "providing a basis for estimating the degree of technical change" but worried that it might not be possible to "determine the volume of 'real output' that *would* have been produced had the techniques remained unchanged", and that if the bias inherently built in the fixed-base or Laspeyres-type input and output indices might have "a tendency to overstate technological improvement" (Friedman, 1938: 126-127).

Hicks, who also worked on a similar index approach to gauging efficiency, considered institutional conditions that could allow the index to coincide the optimum productivity with the optimum welfare of an economy. He was highly concerned about the validity of such an index approach if the real world did not satisfy the required conditions of perfect market

competition, marginal-cost pricing and constant returns to scale, but instead distorted by improper indirect taxes and organizations (1940: 118-123).

The “measure of our ignorance”

This efficiency index idea seemed more empirically appealing than conceptually alluring. There were soon two empirical strands that emerged attempting to capture the “residual”. One strand pursued a production-function path initiated by Charles Cobb and Paul Douglas in 1928 to measure the “residual” as a shifter of the Cobb-Douglas production function, beginning with Tinbergen in 1942, followed by Tintner (1944), Johnson (1950) and Solow (1957). The other strand followed the index number approach to the “residual” practiced at the NBER under the leadership of Simon Kuznets, beginning with Stigler in 1947, followed by Schmookler (1952), Fabricant (1954), Kendrick (1955) and Abramovitz (1956).

While the “residual” did not seem to be too difficult to estimate in these empirical exercises, it was not clear about what it actually captured. The estimated “residual” confused researchers when its value appeared to be too large to be true. Researchers often interchangeably used the terminology of “efficiency”, “productivity” and “technical change” in the same studies. Lack of theory that can integrate the “residual” into economic growth apparently obstructed the conceptualization of the “residual”. This situation led to the famous yet seemingly discouraging message by Abramovitz who labeled the “residual” as a “measure of our ignorance” (1956: 11).

3. THE CONCEPTUALIZATION OF TFP AND ITS INSTITUTIONAL IMPLICATIONS

The “Solow residual”

What made Solow’s contribution seminal was an explicit integration of his growth theory (Solow, 1956) into the shift of the production function and hence a coherent connection to macroeconomics developed subsequently. It is Solow who started the conceptualization of TFP. Solow began with an aggregate production function with a Hick’s neutral shift parameter A_t and constant returns to scale and deduced the consequences for, and restrictions on, the productivity index (1957: 312-313). A Hicksian efficiency index A_t / A_0 can be derived from his aggregate production function $Q_t = A_t F(K_t, L_t)$ as a ratio with Q_t / Q_0 as the numerator and the factor-accumulation portion of the production function, $F(K_t / L_t) / F(K_0 / L_0)$, as the denominator. Notably, as put it by Hulten (2001: 8), “the indices A_t and S_t are identical in special case, but A_t is the more general indicator of output per unit of input”.

Solow’s non-parametric approach to measuring A_t does not impose a specific form on the production function. His solution began with the total differential of his aggregate production function assuming that all input factors are paid by their marginal costs, respectively. He then substituted observable factor income shares, ω_t^K and ω_t^L respectively, for the unobserved factor output elasticities derived from the total differential. Finally, he obtained the “residual growth rate” of output that cannot be explained by the growth in capital and labor inputs, i.e. the growth of total factor productivity, as: $\dot{A}_t / A_t = \dot{Q}_t / Q_t - \omega_t^K (\dot{K}_t / K_t) - \omega_t^L (\dot{L}_t / L_t)$.

The institutional assumptions

Solow’s ingenious solution to the input factor weighting problem, i.e. substituting the observable factor income shares for the unobserved output elasticities of factors with the

assumption that factors are paid their marginal products, explicitly assumes that the economy is fully operated in a perfect market system. In such a system there are well developed institutions to ensure free enterprises that maximize profits through free competition for production resources. Equally important, the role of the government is neutral in that it only provides public goods including maintenance of the market system by closely monitoring its activities and timely removing barriers to the mobility of factors and products.

All these are of course hypothetical but necessary for setting up a general theory that can be used as a benchmark to gauge likely distortions in the real world. This is important for us to examine the China case later. It is just these institutional conditions that ensure factors are traded in competitive markets, subject to marginal cost pricing and hence leading to the competitive allocation of production resources and distribution of national income. In this sense, the shift of the aggregate production function, indicated by the change of TFP, is also conditional on the same institutional assumptions. This is where my institutional interpretation of TFP change sets in.

Externalities and TFP change

Theoretically, as accentuated by Hulten, the Hicksian shift parameter “captures only *costless* improvements in the way an economy’s resources of labor and capital are transformed into real GDP”. Hulten shows that “a change in the income shares can cause TFP to increase, even if the underlying rate of technical change remains unchanged”. This reinforces the key point that “productivity growth is not the same thing as technical change” (2001: 8-10). Nonetheless, Solow did not make it very clear when considering empirical problems saying that he used the phrase “technical change” as “a short-hand expression for any kind of shift in the production function” such as “slowdowns, speed-ups, improvements in the education of the labor force, and all sorts of things” that appear as “technical change” (1957: 312).

New technology or technological progress is crucial to any economy but it should not be confused with TFP change because the former can be purchased but the latter not. The TFP model tells us that a firm’s decision to invest in a new technology or R&D is market-oriented and it incurs costs that are counted as increase in capital and labor inputs (the newly purchased equipment with embodied new technology requires the training of workers who operate the new equipment). It is correct to say that without the new technology or the R&D the new investment would have not happened. Yet, it is a different issue. In a competitive market, any increase in input cost, no matter if it is new technology-related, must be always justified by the change in real output. Market-driven competition not only motivates technical innovation but also appraises whether an innovation is economically viable.

A technological progress as such could benefit the economy at large only if it causes positive externalities through, for example, efficiency-enhancing spillovers to other firms or industries, a rightward aggregate demand shift that expands the final market, costless organizational and managerial innovations, or any combination of these, *ceteris paribus*. Conceptually, all these could be captured by a positive change of TFP. However, this is the theory. There are many challenging real-world problems. Technology-induced positive externalities may take place with different degrees of market imperfections. This means that institutional deficiencies may take a toll on the benefits of technological spillovers. On the other hand, if there exists non-market-based investment in new technology that is large enough to crowd out market-based investment, negative externalities may happen, hence raising the cost of the economy at large. Therefore, instead of enjoying a *costless gain* reflected in a TFP

growth, an economy may suffer from an *immeasurable penalty*, which could be captured by a negative TFP change suggesting a rising institutional cost.

Towards an integration of theory, methodology and measurement

Further developments facilitated the integration of the concept of TFP, the methodology of growth accounting and the way in which the input and output data are constructed and measured. The discovery that the Solow residual index is a type of the Divisia index for continuous-time data (Richter 1966) and the confirmation that the Tornqvist index used by Jorgenson and Griliches (1967) as an approximation to the Divisia index is exact if the production function is in the translog form as developed by Christensen, Jorgenson and Lau in 1973 (Diewert, 1976), allow Solow's continuous formulation to be implemented using discrete-time data. Besides, the potential production function theorem confirms that Solow's marginal productivity conditions are both necessary and sufficient. The theorem also sheds important light on the debate over net versus gross measures of output and capital in the growth accounting (Hulten, 1973).

The 1967 paper by Jorgenson and Griliches is a major milestone in the evolution of the productivity theory and in the integration of the theory into the growth accounting methodology and the measurement. It advances the hypothesis that careful measurement of the relevant variables should cause the Solow measure of total factor productivity to disappear. This is an intellectually appealing idea, given that the TFP index is a residual "measure of our ignorance." Hulten (2001) emphasized that "Careful measurement and correct model specification should *rid* the residual of unwanted components and *explain* the wanted ones". Based on the strict application of the neoclassic production theory, Jorgenson and Griliches introduce a number of measurement innovations into the Solow framework.

One is an application of the neoclassical investment theory (Jorgenson, 1963) to the user cost of capital, $r = (i + \delta)P^I - \Delta P^I$ (where i stands for the rate of return, δ for the depreciation rate, and P^I for the investment price index) in which the measure of the implied i validates the requirement for the constant-returns assumption in the measurement of TFP. Besides, they confirm that output must be measured gross of depreciation if it is to be in line with the accounting system implied by the strict logic of the production theory. Most importantly, they show that capital and labor must be disaggregated into their component parts and weighted by asset-specific user costs. This not only avoids the aggregation bias associated with internal shifts in the composition of the inputs (e.g., a shift from long-lived structures to shorter-lived equipment in the capital stock, or a shift toward a more educated work force), but also ensures a constant-quality measure of heterogeneous inputs, i.e. a conversion from changes in quality to changes in quantity (Jorgenson and Griliches, 1967).

All these have helped to cement the one-to-one link between production theory and growth accounting, hence enhancing our earlier discussion to answer why the "Solow residual" is not a measure of "technical change" at all. No matter how advanced the new technology is and how smart the innovation is, they are counted as part of the inputs as long as they are paid by the investor. Therefore, they must be assessed by real output growth not by TFP change. It is crucial to avoid confusing TFP growth with technological progress. Conceptually, a TFP change captures only the output effect of externalities caused by activities of agents in the market place given the prevailing institutional constraints. In a perfect market system, a TFP change by nature measures technology-induced externalities, which should be positive. However, in the case of institutional deficiencies, a TFP change reflects the net effect of

technological and organizational spillovers and market distortions, which could be negative if the effect of the latter is stronger than that of the former.

To echo Hulten (2001), for Solow “the aggregate production function was a parable for the measurement of TFP”, yet for Jorgenson and Griliches, “it was the blueprint”. The Jorgenson-Griliches mission to fully integrate the productivity theory, methodology and measurement has not yet been accomplished. The most challenging part of the mission appears to be in the areas of data and measurement especially in the latecomer economies that are undergoing rapid technical changes in the absence of well-developed pro-market institutions.

4. THE “CHINA STORY”—A PRODUCTIVITY PERSPECTIVE

I am not intending to develop a full-fledged “China story” in this short note but, guided by the productivity theory, I would like to explore the interactions between major reform-induced institutional changes and China’s growth and productivity performance. Particularly, I would like to attempt the reasoning for the interactions, especially why the former may take a heavy toll on productivity while promoting growth.

The governing institution of China

As Chenggang Xu put it, “understanding how Chinese institutions operate poses a great challenge to economics and political science” (Xu, 2015). To address that challenge, in his 2011 article Xu proposed a framework that characterizes the governing institution of China as “regionally decentralized authoritarianism” or RDA.

“In the RDA regime, subnational governments have influence or even direct control rights over a substantial amount of resources, such as land, firms, financial resources, energy, raw materials, and others. Subnational governments are major players in the bulk of the Chinese economy. Under the supervision of the central government, they initiate, negotiate, implement, divert, and resist reforms, policies, rules, and laws. They drive, influence, or hamper regional/national economic development, macroeconomic conditions, environmental conservation or degradation, social stability, etc. China’s reform trajectories have been shaped by centrally controlled regional decentralization. Spectacular performance on the one hand and grave problems on the other hand are all created or closely associated with this governance structure.” (Xu, 2011: 1079)⁴

Xu indeed considered that a highly centralized political regime that tightly gripped the ideology, political structure and personnel system of the party-state bureaucracy played a key role to ensure that the RDA regime is politically well-behaved (Xu, 2011). However, Xu’s institutional framework could have been enhanced and the mechanism through which the government’s pursuit for growth tends to result in “grave problems” could have been established if the *coherent integration* of China’s politically centralized tyrannical regime or PCT and economically decentralized authoritarian regime or EDA is made more analytically explicit. I tend to use “economically decentralized authoritarianism” (EDA) in general rather than Xu’s “regionally decentralized authoritarianism” (RDA) in particular not only to better correspond to politically centralized supremacy, but to reflect that economic decisions could also be made by state agencies, which are no longer subject to mandatory plans that ignore the

⁴ See Section 2 of Xu (2011) for a full elaboration of RDA. To analyze the economic incentive and coordination mechanisms of the RDA system, the governance structure is modeled as a stylized multiregional governance form (*M-form*), for details see Maskin, Qian and Xu (2000) and Qian, Roland and Xu (2006).

market. In what follows, I explain why the PCT-EDA integration can solve the growth problem but not the productivity problem.

The bitterest economic lesson of the planning era is perpetual inefficiency that could be attributed to not simply the “soft budget constraint” (Kornai 1979 and 1986) but the complete abandonment of the market. It is therefore understandable why almost all reform measures in centrally planned economies are market-oriented. Nevertheless, the fundamental nature of the market system is freedom, which fundamentally challenges any authoritarian power, either centralized or decentralized. The PCT-EDA regime is perhaps the best way to adapt the market system without threatening the centralized political supremacy. It ensures state agencies and local governments manipulate the market to best serve the government’s growth objectives, hence making the party-state bureaucracy “legitimate”.

The PCT-EDA regime has created two powerful and compatible mechanisms for China’s growth, that is, regional growth competition and regional reform experimentation (Xu 2011). In a centrally planned system, the achievement of a growth target relied solely on mandatory and centralized all-encompassing national plans that were carried out by less-incentivized managers and technocrats and supervised by political commissars. In the PCT-EDA regime however, growth appears to be self-propelled. Since all growth and reform efforts at localities are indexed by the local GDP growth rate and assessed by the upper authorities as a political performance indicator, local governments and officials are strongly self-motivated to engage in restless “growth tournaments” with their peers from other localities (Li and Zhou 2005), resulting in increasing misallocation of resources and losses in productivity (Huang 2012; Wu 2016). In this process the PCT regime is crucial. Without PCT-implied political endorsement, the EDA regime alone cannot ensure an everlasting growth tournament because regional government decisions for growth may be challenged for high costs.

In a nutshell, the regime is by nature designed to solve the growth problem regardless the cost. Therefore, productivity is its achilleas heel.

The market condition of the PCT-EDA regime

A strongly self-propelled growth in the PCT-EDA system means an ever-expanding production capacity and hence is conditional on an ever-expanding market to absorb the capacity although the market is inevitably distorted. Considering China’s sheer population size and growth at a superfast pace, the most important market condition should be a continuous globalization in which participating countries must acclimate China’s rapid and aggressive expansion, especially the so-induced new global specialization.

China has desperately pursued the expansion of the market for Chinese manufactured products under the WTO umbrella, but its market manipulation behaviors have caused rising disputes with its major trade partners, best echoed in the on-going China-US trade negotiations. Nevertheless, this progression has been significantly obstructed by the global financial crisis in 2008-2009. Having been burdened by severe surplus capacity, dangerously high debt leverage, and grave problems due to various underpaid costs, China has made extraordinary attempts to sustain the market including the development of a nationwide infrastructural system and the global “Belt and Road Initiative”, yet not tackling the fundamental problems of the PCT-EDA system.

Industries in a cross-subsidization game

Promoting local industries is the key to win the growth tournament. Subsidization is the often-used policy instrument to stimulate producers and attract investors. Yet, industries are linked through input-output systems operating at different locations of the production chain of the economy. Upstream industries are considered strategically important, hence owned or monopolized by the central agencies, whereas downstream industries are administratively within the jurisdiction of regional governments. To fuel the growth competition at localities upstream industries also need support. But to the growth-minded government, whether and to what extent the state subsidizes an industry with a specific type of subsidization depends on the distance of the industry from the final demand especially the international market.

Indirect subsidies are mainly used by local governments to promote export-oriented manufacturing industries producing semi-finished and finished goods, most of which are downstream, labor-intensive industries. Supporting them is crucial for China to timely reap its demographic dividend, hence generating a major source of income. In a sense, regional growth competition raises the public revenue for the central state agencies to directly subsidize upstream industries such as energy-related industries and primary input material producers to strengthen the state power and to support downstream industries. Studies show that the cost of major production factors could be substantially underpaid by Chinese enterprises including energy, land, environment, labor and capital (Huang and Tao, 2010). That profits that are exaggerated by underpaid costs attract new investors, which is one of the major factors that drives the rapid expansion of China's production capacity.

This is by nature a cross subsidization game. Any subsidization is market manipulation that distorts the allocation of resources. In the PCT-EDA regime, the market is surely manipulated to fuel the Chinese manufacturing power house. The key to sustain the game is to ensure downstream industries can grow faster and more efficient than upstream industries and the public revenue generated from downstream industries are able to cover direct subsidies to upstream industries. I may conjecture that downstream industries that are mainly supported by indirect subsidies could be more efficient and productive than upstream industries that receive direct subsidies with administrative interferences. In the former case, enterprises may still behave like genuine market competitors although their competitiveness is arbitrarily enhanced. In the latter case, enterprises may have strong bargaining power in negotiating for cheap resources, but in return they must accept controls from the authorities, which distorts their behaviors and disincentivizes their efforts for efficiency improvement and innovation.

The role of land finance in subsidizing industries

Land has played a key role in subsidizing local industries. In China, all land is either owned by the state or "collectives" representing the state, which is considered an important economic and legal foundation of the PCT-EDA regime (Xu, 2011). Land had no value in the planning era. In regional growth tournaments, "land finance" is used as the major instrument to improve local investment environment to attract investors. Some Chinese economists consider land finance the key to the understanding of the "China miracle" in terms of an extraordinary pace of industrialization and urbanization (Liu, 2017; Zhao, 2014). In my view, the land finance created a market condition for sustaining the PCT-EDA regime.

Not all local governments were winners in competitions for industrial investment. Since land that might be used for industrial investment had to be first developed with basic utilities and infrastructures, losers were dragged into fiscal nightmares. The commercialization of urban housing system opened a new source to fuel local development, hence promoting a new round yet fiercer competition for urbanization across localities. Local governments had to first ensure

the issuing price of land (in fact the user right of land) in the primary market was high enough to support their ambitious urbanization plans. Some could find themselves trapped in seemingly endless subsequent additional investments to make new cities attractive enough to woo property buyers. It is believed that the regional growth competition-driven urbanization fever, together with the central government's tight control over land supply for urban and industrial development, might be responsible for China to experience a premature property bubble that forced resources to shift away from labor-intensive manufacturing to property-oriented industries.^{5,6}

Along with the rising cost, local governments nationwide invented "urban development investment corporations (UDICs) to use land as a collateral to obtain bank loans to finance investment in infrastructures to support local urbanization and industrialization.⁷ The UDIC approach was enhanced in the wake of the global financial crisis and even used as land-based "liquidity" to sustain the growth (Liu, 2017). Now, with nationwide hundreds of ghost towns, standing as an ironic monument of China's hurried urbanization propelled by the PCT-EDA regime, despite mounting debts growth-pressured local governments are resilient to the central government's harsh deleveraging measures.

5. METHODOLOGY AND DATA

Why abandon APF?

I do not intend to provide details on methodology and data and measurement issues. Instead I will brief the key issues and leave interested readers to refer to more technical writings in my early studies. The key point, however, following my discussions in Section 3, is how to satisfy the theory-methodology-measurement consistent approach to the "Solow residual" *a la* Jorgenson and Griliches when there might be flaws in the official statistics.

To examine the growth and productivity performance of an economy like China where governments at all levels heavily influence the economy through regulations and industrial policies or even involve in business decision making process, the widely used aggregate production function (APF) approach is inappropriate. This is because it is implicitly subject to 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 2005).

⁵ According to a survey by the Development and Research Center (DRC) under the State Council, of the limited land supply each year, which was between 0.47 and 0.53 million hectares in 2012, only 15 percent is allowed to be used for commercial housing. However, the income generated from the sale of the land use rights of this amount of commercial land has to finance 30 percent of the land for industrial use, 40 percent for infrastructural development, and 10 to 15 percent for government housing projects (Liu, 2017).

⁶ This prematurity argument is based on the yardstick of stage of development measured by per capita GDP. In the 1990 PPP dollars, by the late 1980s when Japan entered a period with rocketing property prices, its per capita GDP had already reached to a level of around \$15,000, about three times the Chinese level in the mid 2000s (Maddison, 2003; TCB, 2016).

⁷ As cited in Xu (2015: 544), local government borrowings from banks via UDICs have grown extremely rapidly, by about 20 percent per year over the last several years. The outstanding debts of local governments have gone from 15 trillion RMB in 2010 (\$2.46 trillion) to 30 trillion RMB (\$4.92 trillion) at year-end 2013, which is from 27 to 60 percent of GDP. These debts are closely related to the shadow banking sector.

I adopt Jorgenson's flexible aggregate production possibility frontier (APPF) framework, together with the Domar aggregation scheme (Domar, 1961), to account for the industry origin of the growth and productivity performance of the aggregate economy. As elaborated by Hulten (1978), the Domar aggregation establishes a consistent link between changes in industry productivity and aggregate productivity. 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, hence benefiting from a positive externality. Using the same logic, we can explain productivity losses in the case of market distortions due to institutional deficiencies that create negative externalities.⁸

Flaws in official output statistics

It is quite natural for official statistics to be politicized if the growth rates are politicized, no matter targeted or realized. Our alternative GDP estimates for China's aggregate economy have suggested that Chinese official estimates tend to smooth out volatility, cover up external shocks, underestimate price change, and hence exaggerate the real growth (Maddison and Wu, 2008; Wu, 2014). However, it is almost impossible to construct an alternative industry productivity accounts because there are no alternative indicators that can be used as substitutes for the existing official industry statistics at two-digit industry level of details.

A more feasible strategy is to focus on adjusting inconsistencies, filling gaps, and restoring balances between components (industries, types of labor and capital assets) and aggregates in official production statistics. This is what has been pursued in my research with my colleagues and research students since the early 2000s. We restore the conceptual consistency in time and space for the Chinese production accounts guided by the production theory and national accounts principles as well as simple aggregation rules. There is one good example. Chinese official industrial statistics cover only the enterprises that are satisfied with the given output and employment criteria leaving the rest unaccounted. Unlike many studies that work only with the available partial data regardless the underlying imbalances, we estimate the gaps below the threshold with principles for system coherence controlled by benchmark input and output accounts (see more about the data below with references).

Not only has such a theory-guided data reconstruction provided us a concept, coverage and classification-consistent, industry-level productivity accounts that are coherently linked to the official national accounts, but it has also put us in a superior position to logically and systematically assess official statistics. If convincing evidence shows that the official output accounts is indeed fabricated, especially if the output growth rate is exaggerated, other things being equal, the estimated TFP growth rate using our reconstructed official output data will also be upward biased. In this case, our data provides a unique prospect for further exploring the sources of the problem of the official statistics.

The CIP/China KLEMS database

The China Industrial Productivity (CIP) Database is developed following the KLEMS principles to avoid underestimating inputs, thus exaggerating output that could be captured as TFP growth, which is in line with the Jorgenson-Griliches framework (see O'Mahony and

⁸ This method was first used in Jorgenson, Gollop and Fraumeni (1987) to quantify the role of American industries in the changes of aggregate inputs, and more recently in Jorgenson (2001) and Jorgenson, Ho and Stiroh (2005) to account for the role of information technology (IT)-producing and using industries in the US economy.

Timmer 2009).⁹ The current version of the CIP Database (CIP 3.0) consists of 37 industries for the period from 1980 to 2010 and preliminarily updated to 1977-2017 for the present work. Wu (2016b) provides the features of CIP 3.0 data and how to apply the Jorgensonian APPF-Domar growth accounting framework to the data. Details on the construction of output and price index series, labor quantity and compensation matrices, and series of investment and capital stock series are reported respectively in Wu and Ito (2015), Wu, Yue and Zhang (2015) and Wu (2015).

Industry grouping to measure “distance” from the market

My industry grouping and periodization design is to make the growth accounting results easy to interpret against the background of institutional changes. In Section 4, I illustrate a “cross subsidization narrative” in which industries are expected to have different growth and productivity performances depending on their “distances” from to the (final) market or the government and hence the types of subsidies or interferences. I now categorize the economy-wide 37 CIP industries into eight groups to help explore this idea empirically.

First, all 24 industries covered by the industrial sector are allocated into three groups based on their positions in the production chains of the economy or “distances” from the final demand market including the export markets. They are a broadly defined “energy” group including oil and coal mining, petroleum and utilities, a group of industries producing commodities and input materials (C&M) (e.g. basic metals, textiles, chemicals and building materials),¹⁰ and a group of industries producing semi-finished and finished goods (SF&F) (e.g. wearing apparel, electrical equipment, transport equipment and machinery).

The “energy” group is located upstream or on the top of the economy’s production chain, while the C&M group is in the middle and the SF&F group located downstream, close to the end market. Since the “energy” group is considered “strategic importance”, it is monopolized by large, central government-managed state-owned enterprises or central SOEs that can easily access public resources and enjoy direct subsidies, yet for the same reason are also subject to strong state interferences. The SF&F group is opposite and dominated by relatively small-sized and privately-owned firms, both domestic and foreign, providing most of the tax revenue and jobs among all industries. Note that some SF&F enterprises engaged in machinery industries can also be quite large, many of which are operated by state-foreign joint ventures. Finally, the C&M group stays somewhere in between. Since it supplies intermediate materials to the downstream, export-oriented industries, it can also be heavily influenced by the government. This group is used to be dominated by state-owned enterprises. Following reforms, it is now also participated by non-state firms.

All non-industrial industries are categorized into five groups though their “location” in the production chain may be somewhat fuzzy. For apparent reasons, we can let agriculture and construction stand alone, respectively. The post-reform agriculture has been subsidized because of its strategic significance. The role of construction in growth has been rising because

⁹ The CIP/China KLEMS data refers to a RIETI sponsored project to construct Chinese Industrial Productivity (CIP) data using the KLEMS principles promoted by the World KLEMS Initiative at Harvard University. The KLEMS acronym stands for major input variables namely, **K**(C)apital, **L**abor, **E**nergy, **M**aterials and **S**ervices.

¹⁰ The C&M group is the same as the “commodities and primary input materials” or C&P group in my earlier writings on Chinese TFP topics. Since C&P may be confused with the primary factor input, capital and labor, I now abandon the use of C&P.

of land-finance supported urbanization and infrastructure development. Services are divided into three groups with Services I and II covering market services, of which Services I consists of state-monopolized services such as transportation and telecommunication services, and financial intermediaries, which are more upstream, and II covers other market services that are more downstream, and Services III including all “non-market services”, i.e. government administration, education and healthcare.

Periodization to capture major policy regime shifts

Dividing the whole period 1980-2016 into subperiods is also for a better examination of externalities of major policy regime shifts on China’s productivity performance that could be captured by TFP change. In Table 1, I propose to divide this period into seven subperiods for this purpose and list reform measures that could represent major policy regime shifts and their expected externalities. Note that in this periodization I don’t intend to document the reforms with exact official records.¹¹ Rather, I emphasize the actual economy-wide impact of a reform measure implemented by changes of policies in the subperiod as defined. Apart from economic reform measures, I also include major macroeconomics shocks outside of the economy either political shocks or international market shocks.

TABLE 1
EXPECTED EXTERNALITIES OF MAJOR REFORMS AND MACROECONOMIC SHOCKS THAT MIGHT BE CAPTURED BY TFP CHANGE

Subperiod	Reforms & Shocks	Expected Externalities
1977-1984	<i>De facto</i> privatization in agriculture; deregulation of rural enterprises; granting autonomy to state-owned enterprises (SOEs) establishment of special economic zones to promote trade and foreign direct investment (FDI)	Strong positive externalities including a strong positive factor reallocation effect as the economy began growing out of the heavy central planning shadow
1985-1991	Urban and industrial reforms propelled by a new dual-track price system; unprecedented inflation and corruption; banking reform; June 4 th Tiananmen Event ended with a suppression of mass political appeal	Positive externalities enhanced as greater market forces unleashed though mixed with significant negative externalities from the political shock
1992-1996	Deng’s south China trip calling for “bolder reforms”; the official adoption of “socialist market economy”; unification of dual foreign exchange regimes; reform of taxation system to clarify the central-local fiscal relationship; deepening SOE reforms under the flag of “gripping the large and freeing the small”	Positive externalities further magnified as the market was “legalized” and enlarged
1997-2001	Reforms in SOEs and urban housing system; further liberalization of private enterprises; deepening banking reforms; Asian financial crisis (AFC) and its	Great positive spillovers induced by the new reforms,

¹¹ Interested readers may check the contents in this table in Barry Naughton’s revised and updated work on the Chinese economy (Naughton 2018).

	induced long-lasting deflation; policy and legal preparations for joining the World Trade Organization (WTO)	but partially cancelled off by the impact of AFC
2002-2007	Implementation of pro-market regulations as required by WTO; reforms to reap China's post-WTO heydays especially in export and FDI; renewed industrial policies with reemerged large SOEs after consolidation schemes	WTO heightened positive externalities, mixed up with rising negative externalities due to growth competition between localities that distorts the market and factor reallocation
2008-2012	Global financial crisis (GFC) and its induced long-lasting deflation; the government's four trillion rescue package associated by fiscal projects across localities	Negative externalities caused by the GFC shock as well as the huge and increasing government involvement to maintain growth
2013-2017	Industrial policies enhanced to target at ICT-related new economies; anti-corruption campaigns to clean up the public sector and to discipline businesses; "supply-side reform" to reduce surplus capacity and deleverage debt; the "belt and road initiative" to enlarge China's external market	Negative externalities likely overwhelmed because of heavy state interventions in structural adjustment, capacity reduction, and debt deleveraging

6. SCRUTINY OF CHINA'S TFP PERFORMANCE

Industry contributions to value-added growth

The first panel of Table 2 presents my estimates for China's value-added growth using the APPF framework without using the Domar aggregation for inputs, that is, assuming that inputs are identical across industries. I use a full KLEMS-type growth accounting model in which the real value added is deflated using a double-deflation approach (i.e. to deflate output and intermediate inputs by their respective deflators in an input-output accounts to obtain the real output), primary factor inputs (capital and labor) are adjusted for constant quality with their respective user cost weights and their growth rates are weighted by their respective weights in nominal gross output, and the growth of intermediate inputs (energy, materials and services or EMS) is also weighted by their respective weights in nominal growth output.

The first line provides the industry output weighted APPF value-added growth rate for the entire period and each of its subperiods. It shows that based on our reconstructed official output data and using the double deflation approach, China grew by 8.7 percent per annum instead of the official 9.4 (more popularly interpreted as 10.0) percent per annum for the entire period in question (NBS, 2018). If dividing the whole period into pre-WTO, post-WTO and post-GFC periods, i.e. 1977-2001, 2001-2007 and 2007-2017, my estimate is 8.9, 10.5 and 6.9 percent per annum, whereas the official growth rate is 9.5, 11.3 and 8.2 percent per annum, correspondingly. If zooming into the most recent period 2012-2017 or the late post-GFC period, my estimate is 5.8 percent per annum that much more pronounces the growth slowdown than that of the official rate at 7.2 percent per annum. To conclude, despite using the same (official) source data, my APPF weighting approach gives significantly different but conceptually more

accurate growth rate estimates because it takes into accounts industry heterogeneity whereas the APF approach does not.

Below the estimated value-added growth rates on the top line of Table 2, there are two panels. The first panel is the average contribution by industry group in percentage points (ppts) for the entire period and its subperiods. These ppt values reveal not only underlying significant structural changes, but also striking differences in sectoral growth. Summing up the contribution of all eight groups in ppts gives exactly the estimates on the top line, which allows us to examine industry group contributions in terms of the share of value-added growth. One should however bear this in mind that such a way of observing the growth performance of the economy with its industry origin is descriptive only and conditional, and it assumes that the underlying value added to gross output ratio and input to output ratio are constant. The influences of the two ratios are important and captured in the TFP analysis as shown later in Table 3.

The contribution of agriculture to the aggregate value-added growth was 8.8 percent for the entire period. It dropped from about 15 percent in the 1980s to 3.5 percent following China's WTO entry in 2001-2007 and nearly maintained at this share in the early post-GFC period 2007-2012 but went up again to 5.1 percent in the late post-GFC period 2012-2017. The resurgence of agriculture in recent years perhaps reflects the struggle of the economy to adjust for the prolonged GFC impact that caused hundreds of thousands of migrant workers to lose their jobs and return their home villages. This could be somewhat mirrored by the contribution of the construction industry to the aggregate value added. Since this industry employs many migrant workers based on temporary and project-related contracts, its share in value added can serve as a good indicator to the performance of the economy. We can see that it increased from 1.3 percent before China's WTO entry in 1996-2001 to 6 percent following the WTO entry in 2001-2007 but dropped back to nearly the pre-WTO entry level (1.4 percent) in the wake of the GFC. It however rose again most recently as the government promoted infrastructural construction to sustain the growth.

The first panel also shows that on the average of the entire period, the contribution of the energy, C&M and SF&F groups to the aggregate value added was 2.1, 17.5 and 39.7 percent, respectively. As indicated by the subperiod performance, both China's WTO entry and GFC brought about significant changes to the energy and C&M groups, but much less to the SF&F group. The two groups moved in opposite directions. Following China's WTO entry, the contribution of the energy group increased from 5.1 percent in 1996-2001 to 7.3 percent in 2001-2007, meanwhile the contribution of the C&M declined from 25 to 16.4 percent, both substantial in magnitude. Shocked by GFC, the contributions of the two groups nonetheless resumed almost to their pre-WTO positions. Like the change in the construction industry, this may also reflect the rising demand for input materials such as steel products and building materials because of the government's huge investment in infrastructural projects to sustain the growth and the boom of the property market.

All market services maintained a somewhat stable growth in their contributions to the aggregate value added in which services dominated by SOEs (Services I) grew faster than others. On the average of the entire period, the contribution of Services I and II was 12.5 and 18.3 percent, respectively. In contrast, the contribution of non-market services or Services III was negative 3 percent, likely reflecting the most rapid increase in the cost of this industry.

TABLE 2
ESTIMATED INDUSTRY AND FACTOR CONTRIBUTIONS TO CHINA'S AGGREGATE VALUE-ADDED GROWTH, 1977-2017
(Contributions in percentage points, or ppts)

	1977- 1984	1984- 1991	1991- 1996	1996- 2001	2001- 2007	2007- 2012	2012- 2017	1977- 2017
Value-added growth (APPF, % p.a.)	10.22	7.33	10.67	7.50	10.54	8.04	5.78	8.65
	<i>Industry contribution to value-added growth (ppts*)</i>							
- Agriculture	1.65	1.05	0.82	0.48	0.37	0.27	0.29	0.76
- Construction	0.20	0.71	0.30	0.10	0.63	0.11	0.30	0.35
- Energy group	-0.21	0.09	-0.19	0.38	0.77	0.28	0.25	0.18
- Commodities & materials (C&M)	1.20	0.98	2.21	1.87	1.73	1.97	0.92	1.51
- Semi-finished & finished (SF&F)	5.20	2.22	4.70	2.59	4.09	3.08	1.79	3.43
- Services I (state monopolies)	0.60	1.10	1.32	0.99	1.35	1.37	1.00	1.09
- Services II	1.27	0.95	1.35	1.22	2.57	2.16	1.73	1.58
- Services III (non-market)	0.32	0.24	0.17	-0.15	-0.97	-1.20	-0.51	-0.26
	<i>Factor contribution to value-added growth (ppts*)</i>							
- Capital input:	4.78	5.43	7.96	4.90	8.47	8.93	6.68	6.62
- Net stock	5.02	5.32	7.92	5.17	8.54	8.92	6.65	6.67
- Capital composition (quality)	-0.23	0.10	0.04	-0.27	-0.07	0.01	0.03	-0.06
- Labor input:	1.36	1.29	1.49	1.14	0.66	0.71	0.24	1.01
- Hours	1.33	1.22	0.63	0.98	0.60	-0.44	-0.03	0.68
- Labor composition (quality)	0.03	0.07	0.86	0.16	0.06	1.15	0.26	0.33
- Aggregate TFP	4.07	0.62	1.22	1.46	1.41	-1.61	-1.13	1.02

Source: Author's estimates.

Note: *Sum of percentage points (ppts) of the items on the same level is equal to the value of the upper level.

Factor contributions to value-added growth

The second panel of Table 2 presents the sources of China's aggregate growth estimated using the APPF method. As shown in the last column of the table, on average the estimated TFP growth is 1.02 percent per annum for the entire period. Given the estimated 8.65-percent annual GDP growth on the top line, TFP growth merely explained 11.8 percent of China's aggregate growth, whereas capital explains 76.5 percent and labor explains 11.7 percent of the growth. Such a contribution of the TFP growth is significantly smaller than the reported estimates in the literature which often accounted for about 40 percent of China's growth (see e.g. Bosworth and Collins, 2008; Perkins and Rawski, 2008; Brandt and Zhu, 2010).

China's aggregate output growth was increasingly driven by capital inputs along with reforms, captured by the performance of subperiods as defined by major policy regime shifts (see Table 1 for policy regime shifts), but not accompanied by TFP growth except the first subperiod 1977-1984 that experienced the best ever TFP performance largely attributable to the *de facto* privatization in the farm sector and deregulations on rural enterprises. In the meantime, the contribution of labor input declines from its peak in the late 1980s to its all-time low in the most recent period. Before examining China's TFP dynamics over time let us first focus on the growth contribution of capital and labor inputs.

The industrial reform led by the introduction of an innovative double-track price reform in 1984 to stimulate off-planning production resulted an over 50-percent jump in the contribution of capital input to the growth from 46.8 percent in 1977-1984 to 74 percent in 1984-1991, yet considerably reduced the contribution of TFP from 40 percent to merely 8.4 percent (all shares are calculated based on the contribution in ppts in the second panel of Table 2, which is the same hereafter). Such a magnitude of the capital input contribution appears to be maintained in the following period 1991-1996 in which there was an investment boom responding to Deng's south China trip (Table 1). The deepening SOE reforms together with the Asian financial crisis (AFC) substantially slowed down the growth of fixed capital investment, hence reducing the growth contribution of capital input to about 65 percent in 1996-2001.

In 2001-2007, following China's entry to WTO in 2001, the growth of fixed capital investment greatly accelerated, therefore substantially raising the growth contribution of capital to about 80 percent. This however continued. In the wake of the GFC in 2008-2009, to sustain the growth the central government launched 4 trillion yuan-worth state investment projects, accompanied by local projects about four times that value, which nonetheless took a heavy toll on productivity growth. The output became increasingly less responsive to the investment growth and the growth contribution of capital input unreasonably overtook the aggregate value-added growth by 11 percent in 2007-2012 and further by 16 percent in 2012-2017, captured by negative TFP performance over these subperiods.

The contribution of labor input to the aggregate growth declined from nearly 18 percent at its peak time in 1984-1991 to only 4 percent in the most recent period 2012-2017. A striking finding is that physical labor input, measured as hours worked, turned negative at the same time the economy was hit by the GFC. This confirms that China has lost its "demographic dividend" and entered a rapid ageing process for a decade. This is undoubtedly caused by the harsh birth control policy imposed in the early 1970s and further enhanced by the one-child system began in the early

1980s. The policy was adopted to raise savings for the Maoist forced industrialization. Yet, the policy maker completely ignored that the birth control policy was a double-edge sword because while it could enable an earlier harvest of demographic dividend, it would inevitably result in a premature and hardly irreversible ageing process. From a growth viewpoint, the birth control policy shortened the time horizon for China to catch up. This means that although China's pursuit for a faster growth appears to be justifiable, given limited resources, the growth should have been more productive and innovative than a market-determined "normal process".

Nevertheless, the disappearance of physical labor input took place coincidentally with the growth slowdown in the wake of the GFC and the government's unprecedented investment endeavor subsequently to save the growth. This is reflected by the sudden jump in the increase of the effect of labor composition or "labor quality" on the output growth, measured as the difference between cost-weighted homogeneous hours and natural hours, which captures the effect of rising labor scarcity on the rise of labor cost.

China's forty years of reform from a TFP perspective

Factor inputs are affected by policies and institutional arrangements to serve the policies, hence having significant bearing on TFP growth through externalities. To better explore an institutional explanation for the estimated TFP performance, I construct a TFP index in [Figure 1](#) using the time series results for forty years since 1977 as summarized in the last line of the second panel of [Table 2](#). It illustrates China's TFP dynamism against the background of the major policy regime shifts, implying convincingly underlying institutional effects.

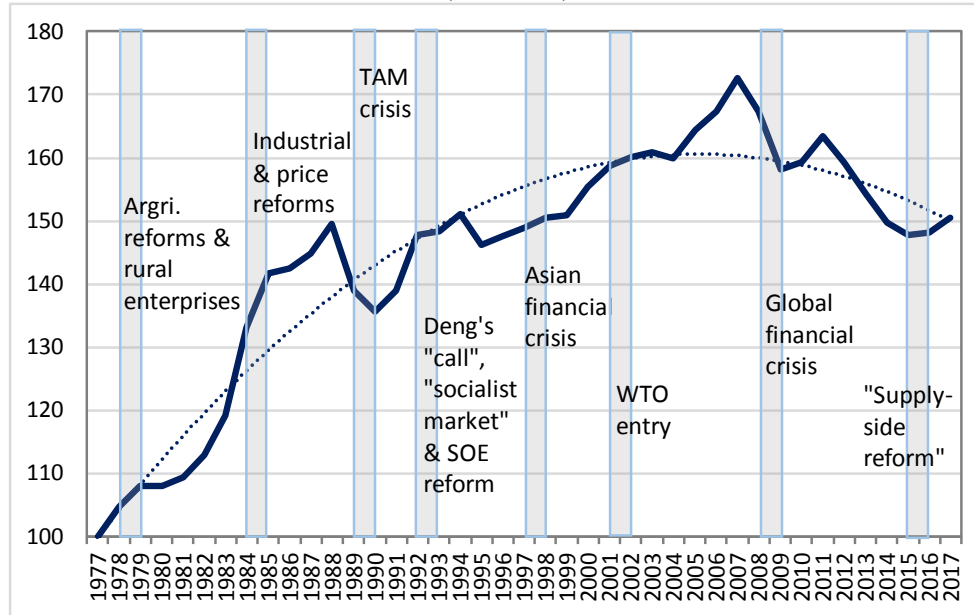
One must bear in mind that the estimated aggregate TFP change is the *net* effect of changes of all driving factors moving in different directions. For example, a pro-market reform measure creates a positive externality, but if another policy intervenes resource allocation at the same time, it may create a negative externality as well. Consequently, the estimated aggregate TFP change is net of the two types of externalities. Historical knowledge on major policy regime shifts in China is thus essential in interpreting the TFP estimates (see [Table 1](#)), but it also helps our understanding with a decomposition of TFP growth into genuine productivity improvement within industries and factor reallocation effect across industries as later presented in [Table 3](#).

The index shows that China experienced the most rapid TFP growth in 1977-1984 when the *de facto* privatization in agriculture suddenly liberalized Chinese farmers from the Maoist collective farming that maintained for nearly a quarter of a century and caused at least 30 million of lives and widely spread rural malnutrition.¹² Yet, the index suggests that this process of productivity improvement somehow stalled when the industrial reform was launched in cities in the mid-1980s with a planning and market dual-track pricing system, while keeping the bulk of the planning machine intact. However, opening to the market, while unleashing vibrant ideas and activities, exposed severe economic and social distortions, hence the incapability of the prevailing institutions in handling the problems. The institutional crisis was the essential force that caused the mass political appeal for democracy in the Tiananmen Square in the summer of 1989. This

¹² The "Great Famine" not only directly caused 30 to 40 million premature deaths (Banister 1987, Dikötter 2010 and Yang 2008), unprecedented in the peacetime human history, but also caused severe malnutrition to those survived.

political crisis is somehow well captured in my TFP index, shown as a momentous productivity shock in the TFP index.

FIGURE 1
INDEX OF CHINA'S AGGREGATE TOTAL FACTOR PRODUCTIVITY, 1977-2017
(1977 = 100)



Source: Author's estimates in time series that are summarized as period average TFP growth rates in Table 2.

Note: Refer to Table 1 for major policy regime shifts and external shocks.

It was Deng Xiaoping's pragmatic call for bolder reforms during his 1992 southern China trip that eventually ended the 1989 crisis-induced ideological debate within the Communist Party and steered China to return to its reform track. The reform measures were unprecedented because the Party decided to introduce the market system though with a socialist hat and dissolve the state industrial sector along with the reforms of the trade, foreign exchange and taxation systems. It appears that the TFP index trembled throughout these reforms before it took a long ride from the mid-1990s that may be interpreted as a consequence of an overall institutional improvement. In fact, the TFP index kept improving even when the economy was shocked by the Asian financial crisis (AFC) in 1997-1998 and the output growth significantly slowed down. This seems to suggest that more market forces were allowed to restructure the economy during the crisis.

China's WTO entry is expected to be institutionally improving because its participation in the world market was required to be bound by the international market rules. The TFP index indeed shows that China's long TFP ride continued throughout China's post WTO heydays. Nevertheless, the index did not survive the global financial crisis in 2008-2009. This proposes a sharp contrast to what happened in the Asian financial crisis. To save the economy, together with the massive fiscal and monetary injections, the government also administratively implemented harsh and biased restructuring measures in the name of "supply-side reform", which however, as Figure 1 shows, caused productivity to deteriorate. Thus, my conjecture that China's WTO entry is institutionally improving could be wrong. The WTO effect on China's institutional change was not strong enough to ensure a more market-based restructuring during the crisis. In fact, if adding

a polynomial trend to the TFP index, it suggests that China's TFP trend growth already began to decelerate in the 1990s and further in the 2000s alongside intensified growth competition among local governments that took a toll on productivity. The TFP trend growth finally turned negative right after China's WTO entry. It is not overstressed to claim that this TFP index has well captured the institutional problems in the Chinese economy.

On the industry origin of China's TPF growth

As Table 3 shows, by integrating the Domar aggregation scheme into the APPF framework we can decompose the aggregate TFP growth into two effects with one as the "Domar-weighted TFP growth effect" for individual industries and the other as the "factor reallocation effect" across industries for capital and labor, respectively. Note that the top line of Table 3 provides the same estimates of the aggregate TFP growth as those of the bottom line in Table 2.

The Domar aggregation uses an industry-specific weighting scheme that takes into accounts the ratio of the gross output of individual industries to the final demand of the economy to capture the effect of productivity changes transmitted across industries through input links from upstream to downstream industries. Some of the effect is cost-related and measurable, therefore entering the *denominator* of the TFP equation as part of the inputs, whereas the rest is costless, immeasurable externalities that affect the *numerator* or the output of the TFP equation. Whether this could enhance or weaken the aggregate TFP performance depends on the given institutional settings. In theory, regardless any short-run volatility, for an economy with well-developed, pro-market institutions, the change of TFP should be non-negative. In other words, the output growth should not be exceeded by the input group regardless short-run fluctuations. It is not difficult to support this proposition with rational behaviors of producers in a competitive market.

The "reallocation effect", on the other hand, shows how the shifts of capital and labor resources across industries can influence the aggregate TFP change. Obviously, the aggregate TFP growth will accelerate if capital and labor move to more productive enterprises or industries of the economy even if the prevailing productivity of individual industries remains constant. Yet, the opposite may happen if resources are allocated to less profitable enterprises or industries, or if enterprises are prohibited from withdrawing from non-profitable businesses. The aggregate TFP change that can be attributed to the factor reallocation effect is a net effect of capital and labor shifting in the contrary directions.

In Table 3, the reported industry-origin estimates of TFP growth using the Domar weights suggest distinctive differences among Chinese industry groups in terms of productivity performance. This implies that Chinese industries are indeed exposed to different institutional environments because of different ownerships, different degrees of government intervention and subsidization, and different exposures to the market competition. Such differences could be however expected because of China's "gradualist" approach, or more accurately, piecemeal or opportunistic approach to the reform that tends to liberalize market-based activities while trying to protect the interest of the party-state bureaucracy and the vested interest groups nurtured in the old planning system or emerged in such a "gradualist" reform environment.

TABLE 3
DOMAR-WEIGHTED TFP GROWTH AND REALLOCATION EFFECT IN THE CHINESE ECONOMY, 1977-2017
(Growth in percent per annum and contribution in percentage points or ppts)

	1977- 1984	1984- 1991	1991- 1996	1996- 2001	2001- 2007	2007- 2012	2012- 2017	1977- 2017
Aggregate TFP growth (%)	4.07	0.62	1.22	1.46	1.41	-1.61	-1.13	1.02
<i>Industry contribution to aggregate TFP growth (ppts)</i>								
1. Domar-weighted TFP growth ^{**†}	2.03	0.06	0.60	1.90	1.36	-2.37	-1.17	0.44
- Agriculture	0.12	0.55	0.46	0.00	0.32	0.07	0.04	0.23
- Construction	-0.19	0.30	-0.35	-0.39	0.27	-0.51	-0.09	-0.11
- Energy group	-0.96	-0.75	-0.91	-0.05	-0.24	-0.48	-0.01	-0.52
- Commodities & materials (C&M)	-0.54	-0.47	0.68	1.88	0.42	0.44	0.62	0.34
- Semi-finished & finished (SF&F)	3.70	0.54	2.39	2.06	1.84	0.68	0.92	1.77
- Services I (state monopolies)	-0.32	0.31	-0.18	-0.28	0.33	0.37	-0.30	0.00
- Services II	0.33	-0.38	-1.00	-0.84	0.23	-1.03	-1.30	-0.49
- Services III (non-market)	-0.10	-0.04	-0.49	-0.49	-1.81	-1.92	-1.04	-0.79
<i>Factor reallocation contribution to aggregate TFP growth (ppts)</i>								
2. Reallocation of K [*]	1.05	0.05	0.02	-0.50	-1.05	-0.06	-0.42	-0.09
3. Reallocation of L [*]	0.99	0.51	0.59	0.06	1.09	0.83	0.46	0.67

Source: Author's estimates.

Note: *Sum of percentage points (ppts) of items 1 to 3 is equal to the value of the first line. †Sum of all sub-items is equal to the Domar-weighted TFP change.

Let us first focus on the industry origin of China's aggregate TFP growth estimated by the Domar weighting scheme under Item 1 of Table 3, which may help better understand the role of different industries in China's productivity performance. As Table 3 shows, China experienced the best Domar-weighted TFP growth in the early reform period 1977-1984. It appears nonetheless that it was not the farm sector undergoing the *de facto* privatization and the sanction of rural township and village enterprises (TVEs) but the SF&F group that was most benefitted from the positive spillovers of the reform. In fact, most of rural TVEs fell in the SF&F category in our grouping. Besides, business and consumer services (Services II) that suffered from a long suppression under the central planning also enjoyed a positive TFP growth. Meanwhile, the state-monopolized energy and C&M groups were affected by negative spillovers that could be attributed to increasing market-oriented reforms with incompatible institutions.

During the subperiod 1984-1991, although the combined effects of industrial reforms, driven by the planning-market double-track price experiment, and policy retreats after the Tiananmen shock in 1989 resulted little the Domar-weighted TFP growth, individual industry groups still perform idiosyncratically. During this period, agriculture became the best TFP performer in time and space enjoying most of positive spillovers of the reform, followed by the SF&F, Services I and construction groups, whereby the energy and C&M groups continued suffering from negative spillovers. In the following two subperiods, 1991-1996 and 1996-2001, the TFP performance of the SF&F group was considerably enhanced along with the unprecedented SOE reforms. Besides, the contribution of the C&M group to the Domar-weighted TFP growth for the first time also turned strong positive in 1991-1996 and then almost matched that of the SF&F in 1996-2001. Since the C&M provided supplies to the SF&F group, such an improvement clearly indicates that institutional changes were highly biased towards the most end-market-oriented SF&F industries that were in line with China's comparative advantage, hence income generating (recall the cross-subsidization proposition discussed in Section 4).

Despite continuous reforms, the TFP performance of individual industries was still in sharp contrast, suggesting that China's "gradualist" reform approach failed to timely create a more integrated internal market. Even China's WTO entry did not help create a universal pro-market environment. Growth competition-pressured local government interventions through various types of subsidization to promote local urbanization and industrialization, as well as investment by the central state agencies to improve nationwide infrastructure, were mainly responsible for the problem (Jinglian Wu, 2008). Subsidies in the short run may have a positive output effect on the subsidized industries because they reduce costs, but in the long run they will induce negative spillovers by crowding out non-subsidized but likely more efficient enterprises or industries, thus enhancing institutional deficiencies. This may explain why the TFP contribution of construction and Services I, consisting of state monopolized transportation, telecommunication, and financial services, turned around significantly from noteworthy negative values throughout the 1990s to positive values in 2001-2007.

Strengthening government interventions while increasing market exposures along with the reform, especially the WTO participation, unavoidably requires new administrative functions of the government and therefore a continuous enlargement of the size of the administrative bureaucracy but not necessarily its efficiency. In terms of TFP growth, the performance of the public sector industries, grouped as Services III, declined substantially from a nearly, and reasonable, neutral position in the early reform period to the ever worst among all industries

following first China's WTO entry and then the GFC shock. This result could be expected from the TFP performance of a highly pro-growth PCT-EDA regime that is willing to bear any economic cost (see Section 4).

Notwithstanding the government's trillions of infrastructural investments to sustain the growth, innovative "belt and road initiative" to enlarge China's market, and harsh "supply-side reforms" aiming to restructure the economy, Table 3 shows that China's Domar-weighted TFP growth suffered from a seemingly durable absolute decline over the post-GFC decade. The performances of individual industry groups remained highly idiosyncratic, but their relative positions reshuffled. In such a policy environment, the importance of both the C&M group and Services I rose as expected. Thanks to heavy subsidies and supportive institutional arrangement, they were the only groups that increased their contribution to the Domar-weighted TFP growth in 2007-2012, yet certainly taking a big toll on the TFP performance of the others.

The effect of factor reallocation on TFP growth

All these suggest the existence of resource misallocation in the economy. Table 3 shows that China has an atypically large reallocation effect on TFP growth, which is not usually observed in market economies. For example, based on their empirical work on the US economy in 1977-2000, Jorgenson, Ho and Stiroh (2005) showed that first, the factor reallocation effect on TFP growth was generally negligible and second, if it was non-negligible for some subperiods, as reported in Jorgenson, Gollop and Fraumeni (1987), the capital reallocation effect was typically positive and the labor reallocation effect was typically negative for the US economy over the period 1948-1979. 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.

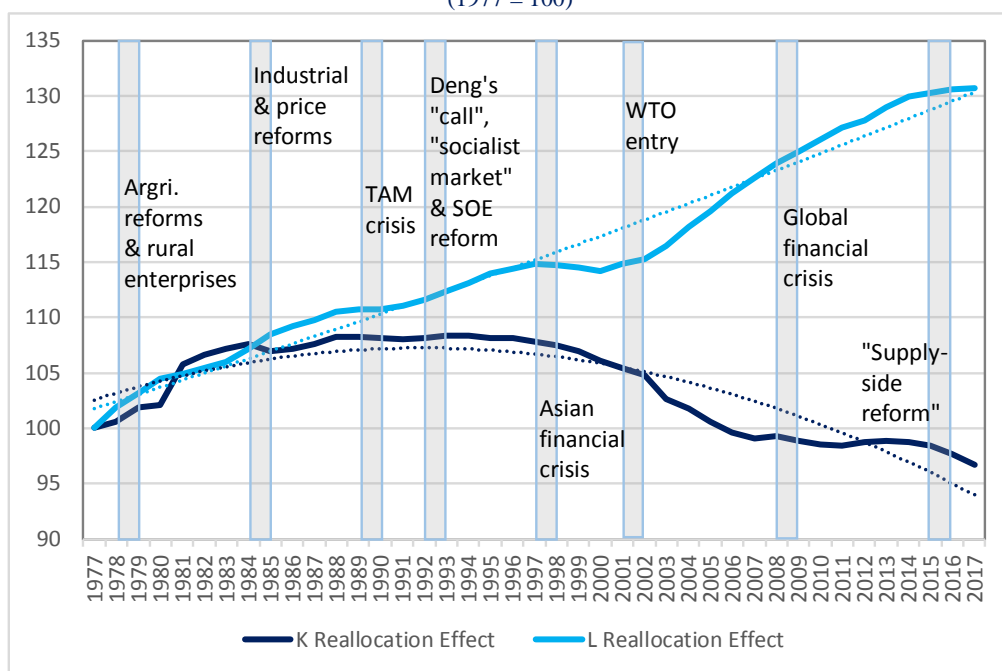
As in Wu (2016) and Wu and Liang (2017), what I have found is opposite to what reported in Jorgenson, Gollop and Fraumeni (1987). China's labor reallocation effect on TFP growth remained generally positive over time, which suggests that the labor market was much less distorted than the capital market, benefitting from increasing labor mobility along with the reforms. Notably, the post-WTO period experienced the most significant TFP gain from labor reallocation (1.09 ppts in 2001-07) which could be driven by the rapid expansion of export-oriented and labor-intensive industries that were in line with China's comparative advantage. Yet, something institutional is hidden here. Part of the productivity benefit from the labor side could also be attributed to the strictly banned collective bargaining in China. Thus, even if all the "unwanted" factors have been removed from the "residual", one has to bear in mind that TFP growth is a net measure of externalities likely moving in different directions, which makes the interpretation tricky if lacking a good knowledge of the economic system in reality.

The capital reallocation effect on TFP growth is opposite to the labor reallocation effect, especially since the 1990s. The earlier reform period indeed saw an improvement in the capital reallocation effect because of a partial removal of the distortions inherited from the central planning period. However, inefficient capital reallocation began to appear again from the late 1990s when consolidated large state-owned enterprises (SOEs), mostly upstream, reemerged after the government's SOE reform program "gripping the large while freeing the small", and continued to rise throughout the period after China's WTO entry. This is nonetheless the government's

deliberate attempt to “counterbalance” China’s increasing exposures to international competition after joining the WTO. Meanwhile the enhanced growth competition between local governments could also cause inefficient allocation of resources, mostly capital. Thus, the so-induced negative externalities could be overwhelming and productivity-damaging. This could be the key reason behind China’s potential productivity slowdown since the mid-1990s despite continuous reforms till the global financial crisis as shown in Figure 1.

In Figure 2, to help intuitively examine the dynamics of the factor reallocation effect on the TFP growth in China, I construct an index based on the initial year 1977 for capital and labor, respectively, using my time series estimates behind Table 3.

FIGURE 2
CHINA’S FACTOR REALLOCATION EFFECT ON TOTAL FACTOR PRODUCTIVITY GROWTH, 1977-2017
(1977 = 100)



Source: Author’s estimates in time series that are summarized as subperiod average reallocation effects in Table 3.

Note: Refer to Table 1 for major policy regime shifts and external shocks.

To help our examination of the dynamic impact of factor reallocation on China’s TFP growth, the labor reallocation effect index is fitted with an exponential trend, whereas the capital reallocation effect index is fitted with a polynomial trend. The two indices diverged after the mid-1980s, especially after the Tiananmen crisis. The labor reallocation effect index overcame the AFC shock as well as the subsequent long-lasting deflation in 1997-2000 and then managed to return to its trend in the mid-2000s. It remained above its trend since the GFC despite an apparent slowdown following the “supply-side reform”.

The capital reallocation effect index stopped improving in the wake of the Tiananmen crisis. It is also a big surprise that it was little affected by the new reform wave promoted by Deng’s south China trip in 1992. While the labor reallocation effect index managed to survive the AFC-deflation

period, the capital reallocation effect index deteriorated and even further departed downward from its declining trend. This finding supports my conjecture that the growth competition between local governments may (temporarily) solve the growth problem but not productivity problem and the growth competition for faster industrialization and urbanization following China's WTO entry indeed caused severe misallocation of capital. Besides, we also observe that the capital reallocation effect index further worsened alongside the implementation of the "supply-side reform" in 2015.

7. CONCLUDING REMARKS

My ending remarks are not going to repeat what I have extensively discussed throughout this research note. What I would like to emphasize is that for identifying productivity or efficiency problems and their coherent links to the underlying institutional deficiencies that face many of today's emerging economies, the neoclassical theory of TFP is almost ready for use without a considerable new endeavor. The most demanding part of such a pursuit is in the domain of data and measurement that requires quite substantial research resources. The work must be guided by the same productivity theory to ensure a strict, coherent consistency of the theory, methodology and measurement. I show that such efforts are indeed paid off in the China case.

If someone takes this note as a market manifesto for productivity I would not make a rebuttal. It is needless to reemphasize that why productivity growth is the key for a developing economy to accomplishing its mission of catching up to the world technological frontier. To this end, well developed and functioned pro-market institutions are indispensable. This is where a truly responsible government could play a significant role without affecting its neutral position in facilitating the development. If the government is encouraged to get involved in business decision making with a strong belief that a successful catch up is only possible when the government can aggressively "create the market" with any means available (Wen, 2016), it would be all but productivity destructive. In this note, we have shown that the "China model of growth" (so far) may not be easily challenged by its success in growth rate but definitely failed the test for efficiency and productivity promotion. China's productivity problem has a deep institutional root.

In any attempt trying to insightfully describe the "China model" and the key factor that has made China today, it is unavoidable to make a choice between the government and the market, or between the "socialism" and the "capitalism". We should not forget that all the gains so far in China were brought about by spontaneous market forces through various "marginal (pro-market) revolutions" (Coase and Wang, 2012). It could have happened that way only because the long tensions within the traditional Party-State system self-created a "crack" and the Chinese pragmatic political philosophy tolerated the market capitalism to sneak in as long as it could help solve the pressing income growth problems without challenging the system. Therefore, only gradualist or piecemeal reforms in practical directions could be accepted. A genuine political or institutional reform has never been truly on the reform agenda. The cost of such reform gradualism is that it creates new vested interest groups while trying to comfort the old ones in a highly distorted institutional setting that is intertwined with the prevailing Party-State system. This makes an institutional reform extremely difficult if not impossible.¹³ It is rather naïve to appeal for "returning

¹³ In the debate about "backward advantage" or "backward disadvantage" between Justin Lin and Xiaokai Yang in the early 2000s, Yang (2000, also see Sachs, Woo and Yang, 2000) was a sheer idealist when warning that failing to initiate a constitutional transition China's growth could not be sustainable, which put the government in a political

to Deng” because it was Deng’s pragmatism that has brought us to today. There is no lack of the pragmatic Dengism but a political wisdom to dissolve the China dilemma.

In a foreseeable future of my generation, whatever the new technologies may change the economy, the market is still indispensable especially in terms of the market for ideas (Coase, 1974), which is deemed fundamental for innovation hence productivity growth. In any economy or society, a powerful and all-embracing government may be able to “create” anything, including “the marketplace”, but surely not innovative ideas. Indeed, a largely forgotten fact in China’s reform history is that it was the intellectual appeal for “reading without limit” in 1979, which was soon translated into “ideas without limit”, that helped quickly spread the call for “seeking truth from the facts”, hence making market capitalist-oriented spontaneous changes tolerable and eventually accepted as the pragmatic goal of the reforms.¹⁴ Therefore, instead of calling for the market for ideas, we should believe that as long as the government is confined to the public goods sectors and the constitutional freedom is ensured, the ideas will emerge vigorously and find their ways to make the market thrive.

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dilemma as either way was a survival challenge to the regime. Yet, Lin’s (2003) sheer pragmatism only guided him to call for grabbing all opportunities to quickly close up the technological gap with the frontier economies.

¹⁴ “Reading without limit” is the title of the editorial article of the initial issue of *Reading (Dushu)* in 1979, written by Honglin Li. *Reading* is a first intellectual magazine that was permitted by the Party’s propaganda organ for publication after a long suppression of free expression of ideas since 1949, which could be interpreted politically suggestive for new ideas.

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