5. Accounting for the Industry Origin of China's Growth and Productivity Performance, 1980–2012

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Introduction

The substantive slowdown of the Chinese economy in the wake of the 2008–09 Global Financial Crisis (GFC) has added fuel to the long-running debate about the sustainability of China's growth model. Despite the government's unprecedented stimulus package, the official statistics—although often accused of exaggerating the real growth performance, especially in times of crisis (Wu 2014b)—show that China nearly halved its pace of growth, from 13.5 per cent per annum in 2005–07 to about 7 per cent per annum in 2013–15 (NBS 2015: 64–65).[2] While economists have been divided on the nature of the slowdown and the choice of macroeconomic policy, one issue is not so controversial: to achieve sustainable growth, China needs to shift from an input-driven to a productivity-led growth model. This study offers new light on China's post-reform productivity performance, taking into account the role of the government.

In this context, an important question is that while the government has (so far) solved the growth problem since the reform period—particularly in alleviating the scale of the post-GFC growth slowdown—it is unclear whether it has also promoted genuine productivity growth. To ascertain the answer, we explore the *industry origin* of the economy's growth and productivity performance—

1 This study is an update of my 2014 China Update paper on China's industrial total factor productivity (TFP) growth and also a substantial extension of that paper to include all non-industrial sectors. Results similar to those of this study are also reported in the Reserve Bank of Australia (RBA) 2016 China Conference (Wu 2016) and Asian Development Bank Institute (ADBI) 2015 China Conference (Wu 2015a). I am indebted to helpful comments and suggestions on this and/or earlier versions from Kyoji Fukao, Xuehui Han, Mun Ho, Yiping Huang, James Laurenceson, Peter Robertson, John Simon, Ligang Song, Marcel Timmer, Rod Tyers, Yong Wang, Wing Thye Woo and Yanrui Wu, as well as participants at conferences and seminars at ADBI, The Australian National University, Asian KLEMS, Institute of Developing Economies, National School of Development at Peking University, RBA, Shanghai Jiao Tong University, Hong Kong University of Science and Technology and the University of Western Australia. Reported in this chapter are interim results of the China Industrial Productivity (CIP)/KLEMS Database Project supported by the Asian Industrial Productivity Program of the Research Institute of Economy, Trade and Industry and the Institute of Economic Research of Hitotsubashi University. The usual claims apply.

2 The national accounts statistics of this source extend to 2014. The growth estimate for 2015 is based on preliminary estimates available from the National Bureau of Statistics website: stats.gov.cn/tjsj/zxfb/201601/t20160119_1306083.html.

an approach that differs from the one more frequently used in the literature, which concentrates on the aggregate economy. The role of the government can be captured, though indirectly, by the productivity performance of state-monopolised or influenced industries. After all, government interventions are often made through industry-specific policies and supportive institutional arrangements.

This study is both an update and a substantive extension of my 2014 China Update chapter on China's industrial total factor productivity (TFP) growth. Using the latest version of the China Industrial Productivity (CIP)/KLEMS database, which now includes the production accounts of 37 industries economy-wide for the period 1980–2012, I can comprehensively cover all non-industrial sectors of the Chinese economy in this growth accounting exercise.

The rest of the chapter is organised as follows. Section two is a conceptual discussion of the industry-specific role of the government in the context of supporting an economy-wide industry grouping. Section three introduces the Jorgensonian approach to accounting for the industry origin of aggregate growth and productivity performance. Section four proposes an industry-specific grouping strategy to distinguish economic activities by degree of market or non-market environment, the latter defined by the level of government intervention. Section five presents and discusses the results, and section six provides a conclusion.

Considering the role of the government

One important change since the reform period is that government interventions are no longer all-encompassing as they were in the central planning era, which completely abandoned the market. They have, however, become more industry-specific through subsidisation, administrative interference or some combination of both. Subsidies can be made in direct or indirect form. Direct subsidies come with administrative interference that aims to compensate for output losses. Indirect subsidies, in contrast, seek mainly to reduce the producer cost of inputs including energy, land, environment, labour and capital (Huang and Tao 2010). Administrative interference serves the government's interests or strategic plans by controlling or influencing output prices and business operations ranging from managing personnel to the choice of technology. To explore the role of government, we may need to consider distinguishing industries that are subject to different types of government intervention, directly or indirectly, through inputs from other regulated industries.

I argue that whether or to what extent the government uses administrative interference or different types of subsidisation depends on the distance of an industry from the point of final demand, especially the international market. Indirect subsidies have been used by local governments mainly to promote export-oriented manufacturers that make semifinished and finished goods. Most of these downstream industries are labour intensive and therefore crucial for China to reap its demographic dividend in a timely fashion. However, the government tends to get directly involved in upstream industries such as energy and primary input materials that are deemed strategically important in supporting downstream industries. This is illustrated in a flow chart (Figure 5.1) simplified for the industrial economy only.

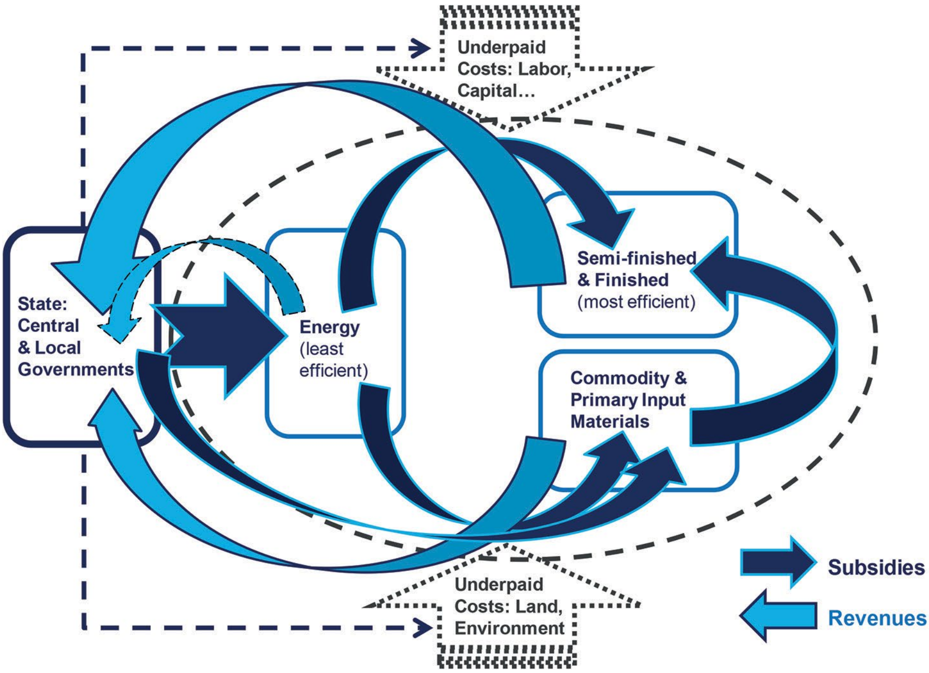

Figure 5.1 'Cross-subsidisation' in Chinese industry: An exploratory flow chart

Source: Author's illustration.

To understand the behaviour of enterprises in such a policy environment and the implications for efficiency improvement and productivity growth, our hypothesis is that industries supported mainly by indirect subsidies are more efficient and productive than those receiving direct subsidies for losses with administrative interference. In the former case, enterprises may still behave like market competitors even though their competitiveness is arbitrarily enhanced. Upstream industries such as oil companies and electricity providers are traditionally dominated by state-owned enterprises (SOEs) and do not conform to China's comparative advantage. Their assumed 'strategic importance' gives

them strong bargaining power in negotiating for government support. In return, they accept controls from the authorities. This distorts their behaviour and acts as a disincentive to efforts for efficiency and innovation.

Figure 5.1 illustrates that the nature of government interventions and subsidies is ultimately a form of 'cross-subsidisation'. The key to sustaining it is that downstream industries must be able to grow more rapidly and relatively more efficiently than upstream industries and the public revenues generated from downstream industries must cover direct subsidies. The cost of negative externalities—that is, the cost that cannot be internalised due to subsidies—must be borne by the public. These negative externalities also play a role in resource misallocation.

To investigate the TFP performance of industries within this interventionist environment, I categorise the 37 CIP industries into eight groups (see Table A5.1), guided by the degrees of government intervention, either direct or indirect. The first step in that process is to divide the 24 industries in the industrial sector into three groups: 'energy', including coalmining, petroleum and utilities; 'commodities and primary input materials' (C&P), such as basic metals, chemicals and building materials; and 'semifinished and finished goods' (SF&F), such as clothing, electrical equipment and machinery. C&P and SF&F have been the key drivers of China's post-reform growth. According to their 'distance' from final demand, the 'energy' group is located upstream, followed by C&P, with SF&F the closest to the final consumer market. The SF&F group will therefore, and as conjectured, be most inclined to receive indirect government intervention.

The non-industrial sectors are divided into five groups, although their locations in the production chain cannot be easily defined. Among them, the agricultural sector serves final demand and also provides intermediate inputs to food processing and manufacturing industries and as such can be an important channel for indirect policies. Similarly, construction delivers both investment and consumer goods. Services are further divided into three subgroups: Services I, consisting of state-monopolised services of important intermediate input industries such as financial intermediaries, transportation and telecommunication services; Services II, covering the remaining market services, which are mainly final demand providers; and Services III, denoted by 'non-market services', including government administration, education and health care.

Further exploring the three industrial groups, the 'energy' group remains largely monopolised, if not completely in the hands of large, Central Government-owned enterprises, due to its 'strategic importance'. Firms in this group can easily access public resources but are subject to strong administrative interference. The C&P group is also considered important for downstream industries and

hence is heavily influenced though less characterised by state ownership. The third industrial group, the SF&F group, consists of all downstream industries including not only private and foreign enterprises, but also SOEs, particularly in heavy machinery industries. The competitive nature of these industries makes it difficult for the government to directly interfere in business decisions. On average, SF&F is more labour intensive than the other groups and therefore more in line with China's comparative advantage. We therefore conjecture that the productivity growth of SF&F will be faster than that of 'energy' and C&P.

Accounting for industry origin of TFP

The aggregate production function (APF) is a widely adopted approach to TFP analysis. It is also 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 labour must receive the same price in each industry' (Jorgenson et al. 2005b: 364–365). Given heavy government intervention and institutional setups that cause market imperfections in China, this approach is inappropriate for the growth accounting exercise in the Chinese economy. This study instead adopts Jorgenson's aggregate production possibility frontier (APPF) framework, incorporating also Domar weights to more accurately account for the contributions of individual industries to the growth of aggregate inputs and output.

The APPF approach in growth accounting abandons the strong assumption of the APF approach that all industries are subject to the same value-added production function (Jorgenson 1966). The Domar-weighted aggregation was later adopted into the APPF framework in Jorgenson et al. (1987) to exercise direct aggregation across industries to account for the role of American industries in the changes in aggregate inputs. It has since been used in Jorgenson et al. (2005a, 2005b) to quantify the role of information technology (IT)-producing and IT-using industries in the US economy. The approach is now the international standard and has also been applied to the Chinese economy in Cao et al. (2009) and Wu (forthcoming).

To illustrate this methodology, I 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 as this allows us to explicitly trace the sources of the aggregate productivity growth and input accumulation to the underlying industries. For the industry-level

production function given by Equation 5.1, each industry, indexed by *j*, purchases distinct intermediate inputs, capital and labour services to produce a set of products.

Equation 5.1

$$Y_j = f_j(K_j, L_j, M_j, T)$$

In this equation, *Y* is output, *K* is an index of capital service flows, *L* is an index of labour service flows and *M* is an index of intermediate inputs 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 utilisation and constant returns to scale, the growth of output can be expressed using the translog functional form as the cost-weighted growth of inputs and technological change (Equation 5.2).

Equation 5.2

$$\Delta \ln Y_j = \bar{v}_j^K \Delta \ln K_j + \bar{v}_{jt}^L \Delta \ln L_j + \bar{v}_j^M \Delta \ln M_j + v_j^T$$

In this equation, $\bar{v}_i^K$, $\bar{v}_i^L$ and $\bar{v}_i^M$ 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 $v_j^M = \frac{P_j^M M_j}{P_j^Y Y_j}$, respectively.

Under constant returns to scale, $v_j^K + v_j^L + v_j^M = 1$, which is controlled by industry production accounts in nominal terms. Each element in the right-hand side of Equation 5.2 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 ($\bar{v}_j^M \Delta \ln M_j$) and TFP ($v_j^T$).

One of the advantages of Equation 5.2 is that it can better account for each input service by different types. For example, it can account for labour services provided by different types of labour 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 the numbers employed or hours worked as homogeneous measures of labour input. The growth of total labour input can therefore be defined as a Törnqvist quantity index of individual labour types (Equation 5.3a).

Equation 5.3a

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

In this equation, $\Delta \ln H_{h,j}$ 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 labour income of industry production accounts.

The same user-cost approach is also applied to K and M to account for the contribution of different types of capital asset (Z_k) and intermediate input (M_m) in production with type-specific, two-period average cost weight defined as $\bar{v}_{k,j}$ and $\bar{v}_{m,j}$, respectively (Equations 5.3b and 5.3c).

Equation 5.3b

$$\Delta \ln K_j = \sum_k \bar{v}_{k,j} \Delta \ln Z_{k,j}$$

Equation 5.3c

$$\Delta \ln M_j = \sum_m \bar{v}_{m,j} \Delta \ln M_{m,j}$$

It should be noted that Equations 5.2 to 5.3c 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 in relation to the data issues in the following section.

Using the value-added concept, Equation 5.2 can be rewritten (Equation 5.4).

Equation 5.4

$$\Delta \ln Y_j = \bar{v}_j^V \Delta \ln V_j + \bar{v}_j^M \Delta \ln M_j$$

In this equation, 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 5.2 and 5.4, we can obtain an expression for the sources of industry value-added growth (that is, measured in terms of input contributions) (Equation 5.5).

Equation 5.5

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

Growth of aggregate value added by the APPF approach is expressed as weighted industry value added in a Törnqvist index (Equation 5.6).

Equation 5.6

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

In this equation, w_j is the share of industry value added in aggregate value added. By combining Equations 5.5 and 5.6, we generate a new expression of aggregate value-added growth by weighted contribution of industry capital growth, industry labour growth and TFP growth (Equation 5.7).

Equation 5.7

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

Through this new expression, we have introduced the well-known Domar weights to the aggregation (Domar 1961)—that is, 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 (Equation 5.8).

Equation 5.8

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

However, this assumption is not likely to hold, in particular in China, as argued above. It is therefore interesting to look at the differences in the two measurement approaches. By subtracting Equation 5.7 from Equation 5.8 and

rearranging, we can demonstrate 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 et al. 2005b) (Equation 5.9).

Equation 5.9

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

In this equation, the *reallocation* terms in the second and third brackets can be simplified (Equation 5.9a).

Equation 5.9a

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

Equation 5.9 expresses the aggregate TFP growth in terms of three sources: Domar-weighted industry TFP growth, reallocation of capital and reallocation of labour 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, and this implies 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* not only had an 'own' effect, but also leads to price changes in downstream industries, and that effect accumulates through vertical links. As elaborated by Hulten (1978), the Domar aggregation establishes a consistent link between industry-level productivity growth and 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 labour (ρ^L) across industries. Each of the reallocation terms is obtained by subtracting the cost-weighted aggregate factor (capital or labour) 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 an especially useful analytical tool for the Chinese case, where strong government interventions in resource allocation may have caused severe market distortions.

Data and periodisation

The CIP database

This study has benefited from a new economy-wide, industry-level dataset that was constructed by the ongoing CIP Project. It is beyond the scope of this chapter to provide an extensive history of studies of the data.[3] I refer interested readers to three working papers for details (Wu 2015b; Wu and Ito 2015; Wu et al. 2015).

In the CIP Project, the principles of industry data construction adhere to the underlying theory and data constraints as expressed in Equation 5.2 and Equations 5.3a–c. This implies that the industry-level data are linked to and 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 A5.1). The reconstruction of the Chinese national accounts is based on different versions of official national accounts compiled under the material product system (MPS) before 1992 and the United Nations System of National Accounts (SNA) thereafter. To construct a time series of Chinese input–output accounts for the period 1981–2010, we use China's SNA input–output accounts that are available for every five years since 1987 and an MPS input–output table for 1981 that is converted to an SNA-type table (Wu and Ito 2015).

3 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, 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.

Nominal accounts are deflated by industry-level producer price indices (PPIs), constructed using official PPIs for the agricultural and industrial sectors and the consumer price index or its components for service industries (Wu and Ito 2015). The work reported in this chapter, however, 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. This choice results from a lack of price data, and is used instead of the double-deflation approach that would otherwise be preferred.[4]

For the required labour data, following earlier studies that analysed the industrial sector only (Wu and Yue 2003, 2010, 2012), CIP has established economy-wide employment series (in both the numbers employed and the hours worked) and compensation matrices for 37 industries. 'Workers' refers to both employees and those who are self-employed (farming households and self-employed retailers and transporters), cross-classified by gender, seven age groups and five educational levels (see Wu et al. 2015).

The construction of net capital stock at the industry level proved most challenging. CIP has reconstructed annual investment flows by industrial sector 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 the nominal wage index of construction workers (H. Wu 2008, 2015a). 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).

Periodisation

To better examine the productivity impact of major policy shifts on the Chinese economy, I divide the entire period covered by the current version of the CIP data, 1980–2012, into four subperiods: 1980–91, 1992–2001, 2002–07 and 2008–12. The first subperiod, 1980–91, is characterised by decollectivisation in agriculture and planning-market double-track price reform with more operational autonomy in the industrial sector. The subperiod ended with the rising inflation that helped to trigger the 1989 Tiananmen Square political turmoil.

4 See Wu and Ito (2015) for preliminary growth estimates at the industry level using the double-deflation approach.

The second subperiod, 1992–2001, began with Deng Xiaoping'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 foreign direct investment drove a new wave of investment in export-oriented manufacturing capacity. Meanwhile, due to the deregulation of private activities, new private firms absorbed huge numbers of state-owned industry employees who lost their jobs in the SOE reforms of the 1990s. However, this also resulted in serious overinvestment. The East Asian Financial Crisis (1997–98) hit the Chinese economy hard and, from 1998, China entered a four-year period of deflation.[5]

The third subperiod, 2002–07, began with China's entry to the World Trade Organization (WTO) in late 2001, and is characterised by counteracting forces. On one hand, WTO entry induced further opening to foreign trade and direct investment, which directed the Chinese economy further towards the market system. On the other hand, consolidated and enlarged state corporations experienced resurgence in the name of protecting national interests in a time of accelerating globalisation. Growth-motivated local governments were meanwhile pressured to undertake rapid urbanisation and heavy industrialisation.

The final subperiod, 2008–12, broadly characterises the aftermath of the GFC. The unprecedented fiscal stimulus package from both central and local governments substantially enhanced the role of SOEs. Separating this period from others helps to examine differences in productivity performance between state and non–state-dominated industries at the time of the crisis.

Results and discussion

Sources of growth in the APPF framework

We now examine China's aggregate TFP performance in the APPF framework. The results are summarised in Table 5.1. According to our estimates, the Chinese economy achieved real output growth of 8.94 per cent per annum in 1980–12. Until the GFC, the SF&F group was the top contributor to growth, followed by Services II (market). In the wake of the crisis, SF&F was marginally overtaken by Services II. On average, over the years 1980–2012, SF&F contributed over one-quarter of real output growth, Services II contributed about 20 per cent and agriculture, C&P and Services I (state monopoly) together contributed nearly

5 China's retail price index declined from 380.8 in 1997 (1978 = 100) to 346.7 in 2003; meanwhile, the producer price index declined from 315.0 to 299.3 (NBS 2014: 123).

40 per cent. The estimated aggregate TFP growth was 0.83 per cent per annum. However, the TFP performance was highly unstable over time, with the highest growth achieved in 1991–2001 (1.63) and the worst in 2007–12 (–2.06).[6]

Table 5.1 Growth in aggregate value added and sources of growth in China, 1980–2012*

	1980–91	1991–2001	2001–07	2007–12	1980–2012
	Industry contributions to value-added growth				
Value-added growth due to (%):	7.61	9.04	11.00	9.23	*8.94*
Agriculture	*1.75*	*1.18*	*0.50*	*0.65*	*1.17*
Construction	*0.38*	*0.64*	*0.68*	*0.73*	*0.58*
Energy	*–0.06*	*0.33*	*0.74*	*0.30*	*0.27*
Commodities & primary materials	*0.90*	*1.49*	*1.57*	*1.31*	*1.28*
Semifinished & finished goods	*1.87*	*2.65*	*2.72*	*2.01*	*2.29*
Services I	*0.92*	*0.64*	*1.47*	*1.20*	*0.98*
Services II	*1.45*	*1.74*	*2.39*	*2.35*	*1.86*
Services III (non-market)	*0.39*	*0.37*	*0.94*	*0.67*	*0.53*
	Factor contributions to value-added growth				
Value-added growth due to (%):	7.61	9.04	11.00	9.23	*8.94*
Capital input:	*5.00*	*6.15*	*8.63*	*9.30*	*6.71*
Stock	*5.00*	*6.22*	*8.71*	*9.30*	*6.75*
Capital quality (composition)	*–0.01*	*–0.07*	*–0.08*	*0.00*	*–0.04*
Labour input:	*1.39*	*1.26*	*1.19*	*1.98*	*1.40*
Hours	*1.34*	*0.88*	*0.71*	*0.34*	*0.92*
Labour quality (composition)	*0.05*	*0.38*	*0.48*	*1.65*	*0.48*
Aggregate TFP	*1.22*	*1.63*	*1.19*	*–2.06*	*0.83*

* Contributions are share-weighted growth rate in percentage
Source: Author's estimates.

Of the 8.94 per cent annual output growth rate for the entire period, the contribution of capital input was 6.71, labour input was 1.40 and TFP 0.83. This means that 64 per cent of the real value-added growth relied on capital input, 27 per cent relied on labour input and 9 per cent relied on TFP growth. The contribution of capital input increased from 46 per cent in the 1980s to 71 per cent post–WTO accession and nearly 100 per cent in the wake of the GFC. On the other hand, the contribution of labour inputs declined from 38 per cent in the 1980s to 19 per cent post WTO accession. This trend reversed after

6 Contact the author for the estimated TFP growth of individual industries.

the GFC and the contribution of labour inputs rose back to 26 per cent—largely attributed to quality improvement rather than hours worked. The contribution of the quality of capital was, on average, insignificant.[7]

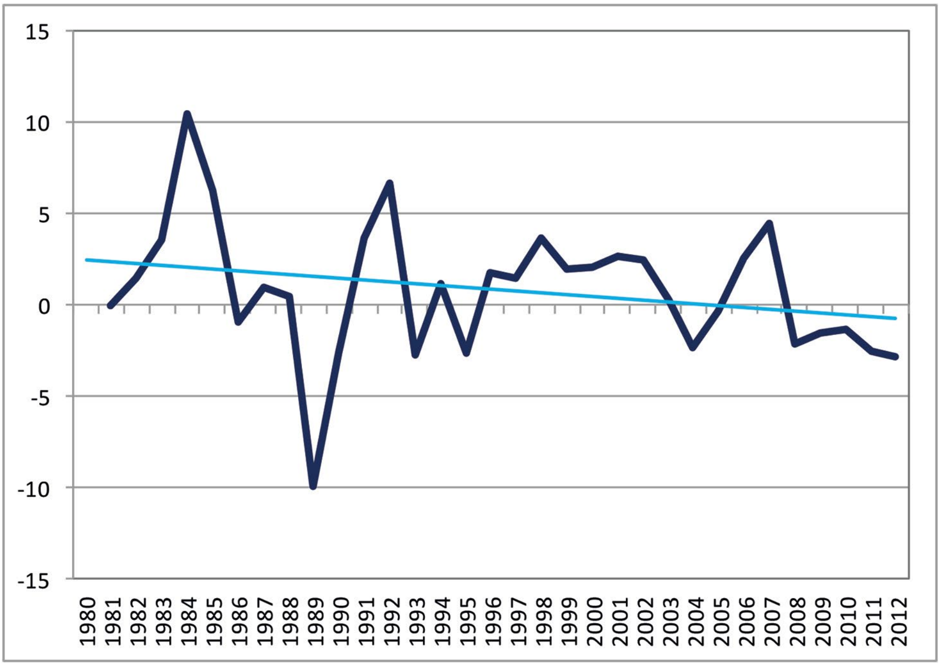

Figure 5.2 TFP growth in China: An APPF approach

Note: 1980 = 100.

Source: Constructed from results shown in Table 5.1.

Constructed using empirical results, Figure 5.2 shows that China's TFP growth was not sustained. In the period 1980–2012, it followed a declining trend. China's first TFP drive was observed from the early to mid-1980s and was associated with successful agricultural reform and the kick-off of nationwide industrial reforms, yet it was short lived. Thereafter, the growth of TFP slowed significantly before collapsing sharply around the 1989 political crisis. The post-crisis TFP recovery was short. The only period that saw stable and sustained TFP growth was 1996–2002. China's post–WTO accession period saw only a short resurgence of TFP growth, in 2006–07, which was interrupted by the GFC. There is little sign that the decline in TFP will shift any time soon.

7 This might be due to the limited set of asset types ('structures' and 'equipment') available in the current CIP database. If a distinction between information and communication technology (ICT) and non-ICT assets could be made, a higher measured contribution is expected.

Table 5.2 presents the results of a decomposition of China's aggregate value added per hour worked into changes in capital deepening, labour quality (composition) and TFP. This enables us to separate the contribution of hours worked from the contribution of genuine labour productivity improvement and its sources. The Chinese economy benefited significantly from the increase in hours worked: the so-called demographic dividend. The dividend, however, declined over time, from 2.83 per cent per annum in 1980–91 to 0.73 per cent per annum in 2007–12. Although value added per hour worked increased from 4.78 to 8.50 per cent per annum, it appeared to be relying increasingly on capital deepening, from 3.51 to 8.91 per cent per annum. More importantly, the growth of labour productivity was not necessarily in line with the pace of capital deepening if we compare the results for 2007–12 with those for 2001–07, and this suggests serious disequilibrium and misallocation of resources that were likely caused by increasing overinvestment.

Table 5.2 Decomposition of aggregate labour productivity growth in China*

	1980–91	1991–2001	2001–07	2007–12	1980–2012
	Growth rates				
Value-added growth (APPF)	7.61	9.04	11.00	9.23	*8.94*
Value added per hour worked	*4.78*	*7.29*	*9.44*	*8.50*	*7.02*
Hours	*2.83*	*1.75*	*1.57*	*0.73*	*1.93*
	Factor contributions				
Value added per hour worked	4.78	7.29	9.44	8.50	*7.02*
Capital deepening	3.51	5.28	7.77	8.91	*5.71*
Labour quality (composition)	*0.05*	*0.38*	*0.48*	*1.65*	*0.48*
TFP growth	*1.22*	*1.63*	*1.19*	*–2.06*	*0.83*

* Contributions are weighted growth in percentage
Source: Author's estimates.

The industry origin of aggregate TFP growth

To explicitly account for differences across industries and their impact on China's aggregate TFP performance, we now introduce Domar weights to the exercise, following the studies of the US economy by Jorgenson et al. (2005a, 2005b). The results presented in the first line of Table 5.3 are estimated with the stringent assumption that marginal productivities of capital and labour are the same across all industries, and are the same as those presented in Tables 5.1 and 5.2. As expressed in Equation 5.9, using Domar weights, the aggregate TFP growth rate can be decomposed into three additional components: 1) the change

of Domar-weighted aggregate TFP; 2) the change of capital reallocation; and 3) the change of labour reallocation. Let us first focus on the first component in Table 5.3, the most important finding of the study.

Table 5.3 Domar-weighted TFP growth and reallocation effects in the Chinese economy*

	1980–91	1991–2001	2001–07	2007–12	1980–2012
Aggregate TFP growth	1.22	1.63	1.19	–2.06	*0.83*
1. Domar-weighted TFP growth	0.60	1.72	0.54	–2.10	*0.52*
Agriculture	*0.99*	*0.75*	*0.82*	*0.68*	*0.83*
Construction	*–0.05*	*0.12*	*0.29*	*0.04*	*0.08*
Energy	*–0.76*	*–0.24*	*–0.32*	*–0.49*	*–0.47*
Commodities & primary materials	*–0.50*	*0.77*	*0.20*	*–0.27*	*0.07*
Semifinished & finished goods	*0.30*	*1.35*	*0.50*	*–0.35*	*0.57*
Services I (market monopolies)	*0.25*	*–0.59*	*0.28*	*–0.02*	*–0.05*
Services II (market)	*0.31*	*–0.42*	*–0.79*	*–0.97*	*–0.33*
Services III (non-market)	*0.06*	*–0.03*	*–0.43*	*–0.71*	*–0.18*
2. Reallocation of K (ρ^K)	0.28	–0.09	–1.03	–0.01	*–0.12*
3. Reallocation of L (ρ^L)	0.35	0.01	1.68	0.06	*0.44*

* Growth in per cent per annum and contribution in percentage points
Source: Author's estimates following Equation 5.9.

On average, across the entire period 1980–2012, China's TFP growth estimated with the Domar weights is 0.52 per cent per annum, which is much slower than the aggregate TFP growth of 0.83. This implies a net factor reallocation effect of 0.44, which will be discussed later. Table 5.3 also shows the contribution of each industrial group to the Domar-weighted annual TFP growth. The highest contributor to the Domar-weighted aggregate TFP growth was agriculture, which contributed 0.83 percentage points. The SF&F group also did relatively well over time (0.57), followed by construction (0.08). The worst performer was the 'energy' group (–0.47), followed by Services II (–0.33) and Services III (–0.18). Such a sharp contrast in TFP performance across industry groups can also be observed over different subperiods. In general, this suggests that treating individual industries as homogeneous within growth accounting may be substantially distorting our understanding of the productivity performance of the Chinese economy.

As was earlier elaborated, the subperiods for examination are set around policy regime shifts that may shed important light on the role of the government. The agricultural sector benefited most from reforms in the 1980s, especially the decollectivisation of farming and deregulation of rural township–village

enterprises. According to our analysis, it specifically contributed 0.83 percentage points to the Domar-weighted TFP growth at 0.52 per cent per annum. Even in the last of our subperiods (2008–12), which was affected by the GFC, it was still the most important contributor (0.68 percentage points) to the Domar-weighted TFP growth (–2.10 per cent per annum). What is possibly surprising is that, although this group's share in nominal gross domestic product (GDP) has been declining over time (see Table 5.1), its contribution to the Domar-weighted TFP growth has remained high throughout the period. This is suggestive of a process in which the agricultural sector is still releasing capital (including land) and labour that have a marginal productivity below the sector's average. By shedding these 'surplus' factors, the average productivity with which factors are used is still growing. Clearly, however, this cannot be a long-run source of growth, as this structural shift is temporary. Future growth must come from the manufacturing and services sectors.[8]

The period 1991–2001 saw the most rapid TFP growth, at 1.63 per cent per annum by Domar weights, and despite the impact of the East Asian Financial Crisis (1997–98) and the subsequent period of deflation in 1998–2003 (see footnote 7). The SF&F group was the most important contributor (1.35 percentage points), followed by the C&P group (0.77 percentage points), driven by unprecedented state sector reforms and opening to foreign trade and direct investment, which allowed the market to play an increasing role in resource allocation. The productivity performance of the construction industry also turned positive for the first time (0.12 percentage points) and even the productivity decline of the 'energy' group slowed substantially, to –0.24 from –0.76 percentage points in the previous period (1980–91).

Despite these group effects, I nevertheless find that China's accession to the WTO at the end of 2001 was accompanied by a slowdown rather than an acceleration of TFP growth: 0.54 per cent per annum in 2001–07, which is less than one-third of the 1.72 achieved over 1991–2001. This puzzling result may be supported somewhat by the observed increasing interventions by local governments in the 2000s aiming to promote local urbanisation and heavy industrialisation (see J. Wu 2008). Table 5.3 shows that in 2001–07, the contribution of SF&F and C&P to TFP growth reduced considerably, from 1.35 to 0.50 percentage points and from 0.77 to 0.20 percentage points, respectively. It also shows that the contribution of construction and state-monopolised Services I (transportation, telecommunications and financial services), both of which are engineered and promoted by the government, significantly increased, from 0.12 to 0.29 percentage points and from –0.59 to 0.28 percentage points, respectively.

8 I am indebted to Marcel Timmer for discussion of the role of Chinese agriculture in the productivity performance of the aggregate economy.

In the wake of the GFC, China's Central Government implemented a RMB4 trillion stimulus package that was also accompanied by RMB18 trillion worth of projects driven by local government financing vehicles. In the face of this stimulus, China's TFP growth declined by −2.10 per cent per annum from 2007 to 2012. Since most of the stimulus package projects were in infrastructure development, construction groups experienced nearly zero TFP growth. Similarly, Services I suffered least (–0.02 percentage points) in terms of productivity decline. The most recent development shows that while the effect of the unprecedented government cash injection has quickly abated since 2012, there are increasing signs that China's surplus capacity in manufacturing is worsening and may take many years to recalibrate to a new, sustainable equilibrium.

The effect of factor reallocation

The slower Domar-weighted TFP growth (0.52) compared with the aggregate TFP growth (0.83) implies that above 60 per cent of the aggregate TFP growth is attributable to productivity performance within individual industries while a less than 40 per cent share goes to the reallocation of capital and labour. Following Equation 5.9, Table 5.3 shows that this effect consists of a positive labour reallocation effect (ρ^L) of 0.44 percentage points and a negative capital reallocation effect (ρ^K) of –0.12 percentage points.

It should be noted that a reallocation effect of such magnitude is typically not observed in market economies. Empirical work on the US economy over the period 1977–2000 by Jorgenson et al. (2005b) showed that first, the reallocation effect was generally negligible and second, if it was non-negligible for some subperiods, the capital and labour reallocation effects generally moved in opposite directions. Jorgenson et al. (1987) also reported the reallocation of capital was typically positive and the reallocation of labour 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 and hence high returns on capital, whereas labour grew relatively slowly in industries with high marginal compensation.

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

I also find that the effect of labour reallocation remained generally positive over time. This may suggest that the labour market was much less distorted than the capital market, having benefited from increasing labour mobility along with reforms. Notably, the post–WTO accession period experienced the most significant gain from labour reallocation (1.68 percentage points over 2001–07), which underwrote the rapid expansion of export-oriented, labour-intensive industries that were then 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 on TFP growth from capital reallocation (0.28 percentage points over 1980–91). The partial removal of the distortions inherited from the central planning period was part of the story. The TFP growth here has, however, since turned negative, especially following China's WTO accession (–1.03 percentage points over 2001–07), likely because of the enhanced role of the government in supporting the state sector's resurgence in upstream industries.

Nevertheless, the results for the post-crisis period from 2008 to 2012 covered in the data deserve greater attention. As shown in Table 5.3, during this period and in contrast with the earlier period, the reallocation effect in both capital and labour approaches zero—that is, 0.06 compared with 1.68 percentage points in the case of labour and –0.01 compared with –1.03 in the case of capital. This rather unusual outcome likely reflects government intervention to keep the economy intact following the external shock. If this finding is true, China's unprecedented government stimulus package did enhance the existing structure of the economy in terms of resource (mis)allocation.

Conclusion

This chapter explores the industry origin of China's aggregate growth and productivity performance for the reform period 1980–2012 using the newly constructed CIP database, and by adopting the Domar aggregation-incorporated Jorgensonian growth accounting framework. This approach provides a highly appropriate analytical tool for investigating the industry origin of aggregate productivity and the effect of resource reallocation across industries in the Chinese economy.

Our preliminary results show that China achieved TFP growth of 0.83 per cent per annum for the entire period 1980–2012. This means that compared with an industry-weighted value-added growth rate of 8.94 per cent per annum, TFP growth accounted for about 9.3 per cent of average GDP growth. This is a result that is much smaller than all previous productivity studies on the Chinese economy based on the aggregate approach—for example, about 40 per cent

contribution estimated by Bosworth and Collins (2008) and by Perkins and Rawski (2008). Our finding is, however, also small when compared with the only work in the literature applying the same approach but specifically to the period 1982–2000 (Cao et al. 2009). The finding herein is in fact about one-third of their result of 2.51 per cent per annum. The differences could come from data construction, measurement, classification and coverage (for example, we have 11 service sectors whereas Cao et al. put everything in one sector).

At the industry group level, and as conjectured, we find that in general industries less prone to government intervention, such as agriculture and the semifinished and finished manufactures, tended to have higher TFP growth rates than those industries subject to direct government intervention, such as the 'energy' group. The fact that the SF&F group maintained positive TFP growth while the 'energy' group experienced persistent TFP declines suggests the existence of 'cross-subsidisation' between upstream and downstream industries in which the government plays different roles to serve its own strategies.

We also found strong effects from factor input reallocation across industries that significantly address the key issue of resource misallocation in the ongoing policy debate. On the one hand, the magnitude of this reallocation effect reflects barriers to factor mobility in the economy and, on the other hand, it suggests potential gains from market-driven reallocation. Institutional deficiencies in the Chinese economy that allow governments at all levels to intervene in resource allocation at their discretion are responsible for resource misallocation, measured here by diminished TFP growth. Therefore, disentangling government from business and allowing the market to correct the cost structure of industries will be important for solving China's structural problems. Indeed, 'restructuring' for healthy and sustainable growth is the most crucial and challenging pillar of the 'Liconomics' agenda. But there is no such thing as the 'right structure', and certainly not without allowing more market-based resource allocation across industries.

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Appendix 5.1

Appendix Table A5.1 CIP/China KLEMS industrial classification and code

CIP code	EU-KLEMS code	Grouping	Industry	
1	AtB	Agriculture	Agriculture, forestry, animal husbandry & fisheries	AGR
2	10	Energy	Coalmining	CLM
3	11	Energy	Oil & gas extraction	PTM
13	23	Energy	Petroleum and coal products	PET
25	E	Energy	Power, steam, gas and tap water supply	UTL
4	13	C&P	Metal mining	MEM
5	14	C&P	Non-metallic minerals mining	NMM
8	17	C&P	Textile mill products	TEX
12	21t22	C&P	Paper products, printing & publishing	P&P
14	24	C&P	Chemicals and allied products	CHE
16	26	C&P	Stone, clay and glass products	BUI
17	27t28	C&P	Primary & fabricated metal industries	MET
6	15	Finished	Food and kindred products	F&B
7	16	Finished	Tobacco products	TBC
9	18	Finished	Apparel and other textile products	WEA
10	19	Finished	Leather and leather products	LEA
23	34t35	Finished	Motor vehicles & other transportation equipment	TRS
24	36t37	Finished	Miscellaneous manufacturing industries	OTH
19	29	Semifinished	Industrial machinery and equipment	MCH
11	20	SF&F	Sawmill products, furniture, fixtures	W&F
15	25	SF&F	Rubber and plastic products	R&P
18	27t28	SF&F	Metal products (excluding rolling products)	MEP
20	31	SF&F	Electrical equipment	ELE
21	32	SF&F	Electronic and telecommunications equipment	ICT
22	30t33	SF&F	Instruments and office equipment	INS
26	F	Construction	Construction	CON
29	I	Services I	Transport, storage & postal services	T&S
30	71t74	Services I	Telecommunications & postal	P&T
31	J	Services I	Financial intermediation	FIN
27	G	Services II	Wholesale and retail trades	SAL
28	H	Services II	Hotels and restaurants	HOT
32	K	Services II	Real estate services	REA

CIP code	EU-KLEMS code	Grouping	Industry	
33	71t74	Services II	Leasing, technical, science & business services	BUS
37	O&P	Services II	Other services	SER
34	L	Services III	Public administration and defence	ADM
35	M	Services III	Education services	EDU
36	N	Services III	Health and social security services	HEA

Notes: 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/2011, largely conforms to the two-digit-level industries of the International Standard Industrial Classification of All Economic Activities (ISIC, Rev. 4) and can be reconciled with the EU-KLEMS system of classification (see Timmer et al. 2007).

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