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HOW IMPORTANT WAS LABOR REALLOCATION FOR CHINA'S GROWTH? A SKEPTICAL ASSESSMENT

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Abstract

Numerous studies report the growth effects from labor reallocation in China to be in the order of 1–2 percentage points per year, which would appear to be a significant fraction of China's per capita income growth. We show that the total factor productivity gains are an order of magnitude smaller, at only 0.25 percentage points per year. There are two reasons for this difference. First, the majority of studies have used a decomposition method that effectively assumes linear production functions. This results in values that are much larger than the more appropriate Denison–Kuznets method. Second, we also allow for sectoral differences in human capital. We conclude that the gains from labor reallocation may have been a far less important source of China's growth than is conventionally thought.

JEL Codes: O4, O41, O1

Keywords: China, dual economy, economic growth, productivity, structural change

1. INTRODUCTION

Two decades of 8–10 percent growth have propelled China from a poor to a middle-income country and removed half a billion people from poverty. Accompanying this growth has been the largest mass migration in history, with 150–200 million people relocating from China's rural sector to the cities. A widely held view is that this mass internal migration has been a major source of China's productivity growth, by facilitating the reallocation of labor from a low productivity

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agricultural sector to high productivity manufacturing and service sectors (Zhu, 2012; Krugman, 2013; *The Economist*, 2013).[1]

This view is supported by an extensive macro-development literature based on two-sector growth models with factor market distortions. The literature includes a variety of studies such as growth accounting studies and calibrated growth models. Recent examples include Brandt *et al*. (2008), Bosworth and Collins (2008), Dekle and Vandenbroucke (2010, 2012), and Cao and Birchenall (2013). These studies typically report large labor reallocation effects, ranging from 1 to 2 percentage points per year.

Nevertheless, the view that labor reallocation has been an important source of China's growth is not ubiquitous. A few studies, such as Cao *et al*. (2009) and Bulman and Kraay (2011), suggest that labor reallocation effects have been a very small, if not insignificant, component of China's growth.

We therefore reexamine this literature in order to gain a clearer view of the contribution of sectoral labor reallocation to China's per capita GDP growth, and why some of these studies may differ so much. Specifically, this paper has two parts. The first part focuses on the distinction between the more widely used "shift-share" method and the standard Denison–Kuznets multi-sector extension of Solow's (1957) growth accounting (Kuznets, 1961; Denison, 1967). Both methods are used in the literature to describe "labor reallocation" effects, but there have been very few attempts to understand the differences between each method or to explore the quantitative implications of using one or the other.

We show that the numbers produced from the shift-share method are more than twice as large as the values obtained from the Denison–Kuznets growth accounting. In light of this, we argue that the literature has failed to provide a clear sense of how labor reallocation has contributed to China's GDP growth and, in the context of a standard competitive model, has perhaps overstated its quantitative importance.

The second part of our analysis builds on the observation that the existing growth accounting literature mostly abstracts from inter-sectoral differences in human capital. This is a potentially important omission, since differences in human capital are a standard alternative explanation for the apparently large inter-sectoral productivity differences. As with Gollin *et al*. (2014), we find that human capital differences do not account for all of the observed average productivity gap. Nevertheless, allowing for these differences reduces the implied growth gains from labor reallocation by approximately one third.

We then show that the combined effect of these two adjustments is that the estimated gains from "labor reallocation" are reduced from a value of 1.76 percentage points per year, to a value of just 0.25 percentage points per year for the

[1]The association between migration and growth has long been a subject of debate in development economics, particularly over the extent to which there is widespread factor misallocation. For example, the Lewis (1954) model was extended by Ranis and Fei (1961), Sen (1967), and Harris and Todaro (1970). These models were criticized by Schultz (1964, 1967) and Jorgenson (1967), who questioned the assumption of sector gaps in the return to labor or surplus labor. Likewise, the literature on dualistic models of development has also been criticized for a lack of empirical evidence and microeconomic foundations (Rosenzweig, 1988; Behrman, 1999). For a recent discussion of the evidence, see Gollin *et al*. (2014).

period 1978–2011. This represents a very small fraction of China's per capita income growth. Hence the gains from labor reallocation may have been a far less important source of China's growth than conventionally thought.

Before proceeding, some caveats are appropriate. First, there are several recent studies that focus on capital allocation across firms.[2] While this literature focuses on firms and misallocation within manufacturing, our focus is on the more conventional development process of labor reallocation across sectors, and hence structural change.

Second, we focus on the shift of labor from agriculture to non-agriculture. While the change in sectoral employment overlaps with rural–urban migration, it is not exactly the same thing. Thus while we occasionally refer to rural–urban migration, the quantitative analysis of this study is specifically focused on the rising share of employment in non-agriculture.

Finally, we are not trying to explain the cause of labor reallocation or develop models that explain this process. We are concerned only with the measurement of the impact of the changing non-agricultural labor share on allocative efficiency and per capita GDP growth in a neoclassical setting. Nevertheless, the quantification of these gains is a necessary first step for quantifying more ambitious theoretical models.

2. Growth and Labor Reallocation in China

2.1. *The Existing Literature*

The view that rural–urban labor migration and labor reallocation have been a key engine of growth in China is prominent in the literature. It features, for example, in discussions by Meng and Bai (2007), Gong *et al*. (2009), Rodrik (2010), Cai and Du (2011), Ge and Yang (2011), Golley and Meng (2011), Yao (2011), Li *et al*. (2012), Meng (2012), and Zhu (2012).[3]

Likewise, there is also a prominent view that the slowing of rural–urban migration implies a significant slowing of China's growth. Examples include Garnaut and Huang (2006), Brandt *et al*. (2008), Cai *et al*. (2010), Huang and Jiang (2010), Rodrik (2010), Cai and Du (2011), and *The Economist* (2013). In particular, Krugman (2013) argues that China's growth is about to "hit its Great Wall" because it is running out of "surplus peasants."

The key proposition underlying this view is that reallocation generates efficiency gains through improvements in resource allocation, as emphasized first by Lewis (1954). In addition to the literature on China, this idea is supported by recent empirical studies that find large differences between agricultural and non-agricultural productivity across many countries (Gollin *et al*., 2014).[4] Similarly, many recent studies have argued that factor misallocation is not only a ubiquitous

[2]These include studies that differentiate firms according to type of ownership, such as private versus state-owned, or the allocation of factors across monopolistically competitive firms that produce distinct varieties. See, for example, Hsieh and Klenow (2009) and also Brandt *et al*. (2013) for a recent discussion with respect to China.

[3]See also Table 1 below for additional quantitative studies.

[4]Gollin *et al*. (2014) observe these productivity gaps but deliberately refrain from drawing implications of these differences for growth, which is the focus of this study.

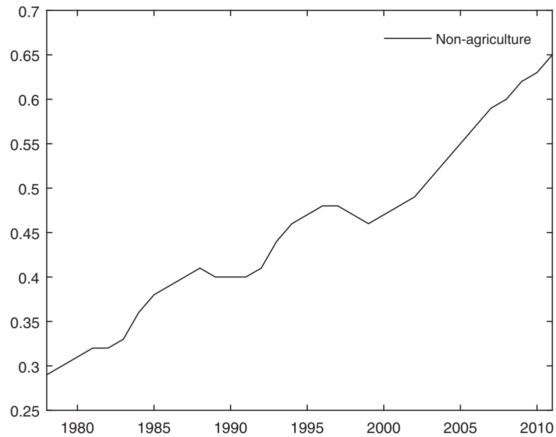

Figure 1. The Employment Share of Non-agriculture in China (1978–2011)

Note: For data sources, see Section 4.2.

feature of developing economies, but also a key part of the growth process (Young, 1995; Vollrath, 2009; McCaig and Pavcnik, 2013).

2.2. *Data on Structural Change*

A preliminary assessment of the data on sectoral labor misallocation and the productivity gap for China is given in Figures 1–4. Figures 1 and 2 show the changes in the employment and output (value added) shares in China.[5] The employment share of non-agriculture rises from 30 percent in 1978 to 65 percent in 2011. Similarly the output share of non-agriculture increases from 70 percent to 95 percent.

Figure 3 shows the average labor productivity (value added per worker) in China in the agricultural and non-agricultural sectors. Clearly, output per worker is lower in agriculture. Moreover, it can be seen that over most of this period, from the mid-1980s to about 2002, per worker income growth in agriculture was much slower than non-agriculture.

Figure 4 thus shows that the productivity gap was about sixfold in the 1980s and, despite the large sectoral reallocation of labor, increased to ninefold over three decades. In terms of the data presented by Gollin *et al*. (2014), this suggests that the sectoral productivity gap in China remains high relative to other countries.

3. Accounting for the Impact of Labor Reallocation

Given this large gap in average labor productivity, the proposition that labor reallocation has resulted in large efficiency gains, and hence significantly contributed to China's growth, seems plausible. Table 1 summarizes the results from existing growth accounting literature on the contribution of labor

[5]In what follows, we refer to sectoral value added, or output net of intermediate inputs, as simply "sectoral output."

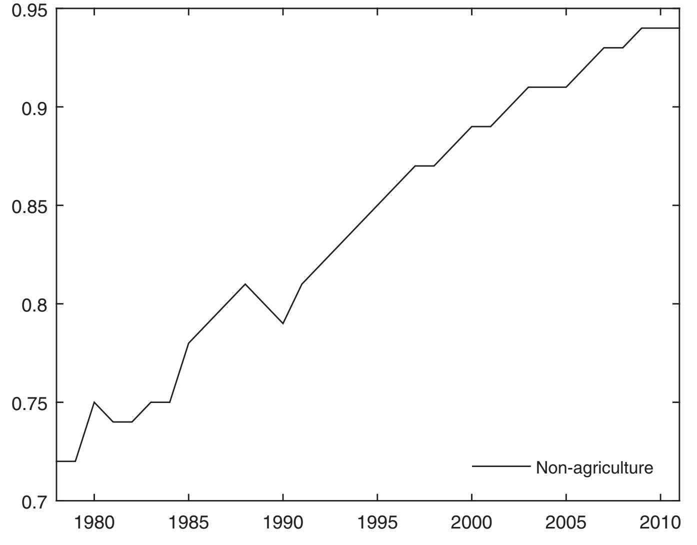

Figure 2. The Value Added Share of Non-agriculture in China (1978–2011)
Note: For data sources, see Section 4.2.

reallocation to China's growth. The reported "reallocation effects" range from approximately zero to over 3 percentage points per year, over any given period.

In interpreting these studies, it is important to realize that two, quite distinct, decomposition methods have been used. In the first method, the "reallocation effect" is calculated as the residual of the difference between aggregate GDP per capita growth and the sum of the growth rates of each sector weighted by their sectoral output shares. This method has been applied widely to quantify what are generally described as "reallocation effects from structural change." Some prominent examples include Kuznets (1957), Nordhaus (1972), Syrquin (1984),

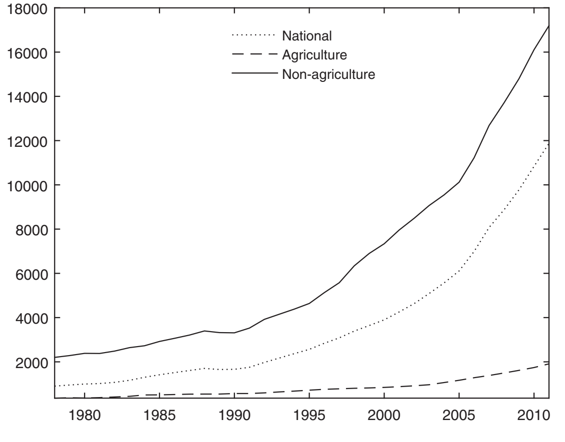

Figure 3. GDP per Worker in China, RMB at 1978 Prices (1978–2011)
Note: For data sources, see Section 4.2.

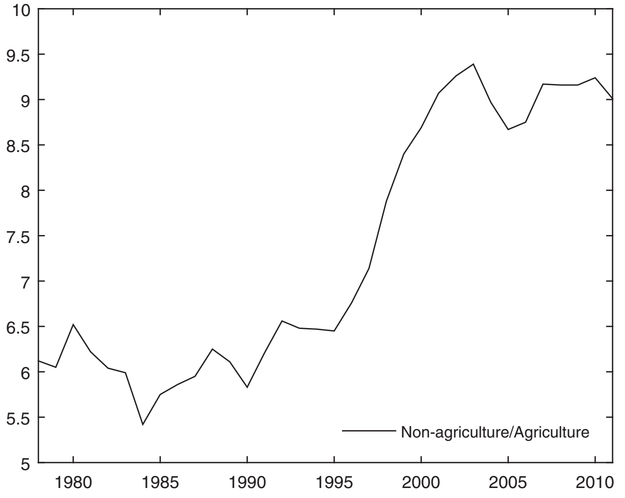

Figure 4. The Productivity Gap in China (1978–2011)

Note: For data sources, see Section 4.2.

Maddison (1998), Broadberry and Crafts (2003), and McMillan and Rodrik (2011). For ease of reference, we refer to this as the "shift-share" method.[6]

The second approach to quantifying the impact of factor reallocation and structural change is multi-sector growth accounting. This is a two-sector equivalent of standard growth accounting, due to Solow (1957), but developed to include multiple sectors by Kuznets (1961), Denison (1967), Robinson (1971), Chenery *et al*. (1975), and Syrquin (1984, 1998). Recent expositions include Barro (1999) and Temple (2001).

As shown in Table 1, the shift-share method remains the most widely used approach in the growth literature on China. Eleven out of 16 studies on China use the shift-share method and only five use standard growth accounting.[7]

Although these alternative approaches to quantifying structural change have been discussed in the literature, there is relatively little discussion of the implications of each method in terms of how they relate to each other, or whether they are quantitatively different.[8] Moreover, it is not obvious that the choice of method

[6]Some studies, such as Fabricant (1942) and Timmer and Szirmai (2000), express the decomposition in terms of the absolute change in sectoral output weighed by the sectoral labor shares. Converting this expression into proportional changes is identical to equation (2).

[7]Other related econometric approaches include Fan *et al*. (2003), Heytens and Zebregs (2003), and Li and Liu (2011). Another prominent growth accounting study on China is Young (2003), although this study focuses only on TFP growth in the non-agricultural sector and does not report estimates of reallocation effects.

[8]The most comprehensive existing statement of this dichotomy is Syrquin (1984). Some discussion of the shift-share approach is also given in Syrquin (1998), Timmer and Szirmai (2000), Temple (2001, 2005), van Ark and Timmer (2003), and Timmer and de Vries (2009). The shift-share method has also been described as a "crude approximation" by Maddison (1998), and Brandt *et al*. (2008) express frustration in assigning a meaningful interpretation to their shift-share based labor reallocation estimates. Temple (2001) and Temple and Wößmann (2006) note that the shift-share approach and the Solow–Denison–Kuznets approach are different, though they do not compare the methods formally. They suggest that the shift-share method may be intended to capture a broader notion of structural change.

TABLE 1
Reallocation Effects in China (% per Year)

	Period	Labor Reallocation
Studies using shift-share method, R_{SS}		
Maddison (1998)	1978–94	1.4
Kuijs and Wang (2006)	1978–93	1.2
	1993–2004	0.8
He and Kuijs (2007)	1978–93	1.3
	1993–2005	1.1
Brandt *et al*. (2008)	1978–2004	1.7
	1978–88	3.4
	1988–2004	0.8
Bosworth and Collins (2008)[a]	1978–2004	1.6
	1978–93	1.7
	1993–2004	1.2
Bloom *et al*. (2010)	1980–2000	1.3
Dekle and Vandenbroucke (2010)	1978–2003	1.5
McMillan and Rodrik (2011)	1990–2005	1.0
de Vries *et al*. (2012)	1997–2008	1.2
	1987-1997	1.0
Cao and Birchenall (2013)	1978–2008	1.8
McMillan *et al*. (2014)	1990–2005	1.0
Studies using Denison–Kuznets method, R_{DK}		
Nehru *et al*. (1997)	1978–95	1.5
Woo (1998)	1979–93	1.1
	1985–93	1.3
Cao *et al*. (2009)[b,c]	1982–2000	−0.02
	1994-2000	0.0
Bulman and Kraay (2011)	1979–2008	0.8
	1979–95	0.9
	1996–2008	0.7
Ercolani and Wei (2011)	1966–2009	1.37

Source: Authors' compilation.
Notes
[a] The number is reported as the total resource reallocation effect.
[b] Study based on gross output rather than value added, but conceptually similar to the Denison–Kuznets approach.
[c] This study also includes adjustments for labor quality.

makes much difference. For example, the study by Maddison (1998) finds an estimated "resource reallocation" effect of 1.4 percentage points over 1978–93, whereas Nehru *et al*. (1997) find a "labor reallocation effect" of 1.5 percentage points over the similar period 1978–95.

Nevertheless, it turns out that this supposition is incorrect. As we show below, analytically and quantitatively, the shift-share approach will typically give much larger "reallocation effects" than the Denison–Kuznets growth accounting method.

3.1. *Alternative Measures of Reallocation Effects*

In order to identify the analytical difference between the shift-share and Denison–Kuznets methods, consider an economy with two sectors, an agricultural sector (A) and a non-agricultural sector (M). Letting Y_M and Y_A be non-agricultural and agricultural output respectively, and choosing the price of agricultural output as the numeraire, GDP is $Y=p\,Y_M+Y_A$. Thus GDP per worker, $y\equiv Y/L$, can be expressed as

$$y=p\,y_M l_M+y_A l_A, \tag{1}$$

where $y_i\equiv Y_i/L_i$, $l_i\equiv L_i/L$, $i\in\{M,A\}$. As shown in Appendix A.1, totally differentiating equation (1), and using a carat to denote a percentage change, $\hat{x}=\mathrm{d}x/x$, gives

$$\hat{y}=s_M\hat{y}_M+s_A\hat{y}_A+((p\,y_M-y_A)/y)l_M\,\hat{l}_M, \tag{2}$$

where $s_A=y_A l_A/y$ and $s_M=p\,y_M l_M/y$ are the output shares of each sector.[9]

This is the shift-share decomposition used by Maddison (1998), Bosworth and Collins (2008), and Bloom *et al.* (2010), among others listed in the first part of Table 1. In a non-China context, this method has also been used to report reallocation effects by, for example, Timmer and Szirmai (2000), Ocampo *et al.* (2009), McMillan and Rodrik (2011), McCaig and Pavcnik (2013), and McMillan *et al.* (2014).

Typically, the first two terms, $s_M\hat{y}_M+s_A\hat{y}_A$, are described as the "within-sectoral contribution" to aggregate growth, and the reallocation effect, R_{SS}, is identified as the last term in equation (2):

$$R_{SS}\equiv((p\,y_M-y_A)/y)l_M\,\hat{l}_M. \tag{3}$$

It can be seen that R_{SS} can be calculated directly from equation (3). Nevertheless, it is more commonly calculated as a residual by subtracting the observed "within-sectoral contribution" terms in equation (2) from observed values of $\hat{y}$.

The rationalization for identifying R_{SS} as the "labor reallocation effect" follows from the fact that if there is no reallocation of labor, then $\hat{l}_M=0$ and $R_{SS}=0$. Alternatively, if there is labor reallocation but labor productivity is the same across sectors, then $p\,y_M-y_A=0$ and again $R_{SS}=0$. Note, however, that a positive value of R_{SS} could also arise even when there is no misallocation in labor market; for example, sectors can have different average products of labor but the same marginal product of labor.

So in what sense is R_{SS} actually what we mean by "reallocation" effects? The usual concept of a labor reallocation effect is the effect of a change in the labor share on total output. Thus a reallocation effect can be defined as

$$R\equiv(\mathrm{d}\,\hat{y}/\mathrm{d}\hat{l}_M)\,\hat{l}_M. \tag{4}$$

It can be seen from inspection of equations (2–4) that the shift-share reallocation effect, R_{SS}, will be equal to this expression only if the values of output per worker, $p\,y_M$, y_A, are independent of the allocation of labor, l_M. That is, $R_{SS}=R$ only if $\mathrm{d}\,\hat{y}_M/\mathrm{d}\hat{l}_M=\mathrm{d}\,\hat{y}_A/\mathrm{d}\hat{l}_M=0$.

[9]We follow the literature in treating the relative p as time invariant; hence $\hat{p}=0$.

Standard production theory, however, suggests that the reallocation of labor will affect the marginal product of each factor due to diminishing returns. Suppose, therefore, that we specify a neoclassical production function in each sector, which exhibits constant returns to scale and diminishing marginal returns to each factor. Each sector consists of homogeneous price-taking firms who choose capital and labor inputs to minimize costs and hence the return to each factor is equal to the value of its marginal product.

To keep the analysis as clear as possible, we assume Cobb–Douglas production functions in each sector, $y_M = A_M k_M^{\beta}$, and $y_A = A_A k_A^{\alpha}$, where $y_i = Y_i/L_i$, $k_i = K_i/L_i$, $L = L_M + L_A$, and $K = K_M + K_A$, with $0 \leq \alpha \leq 1$ and $0 \leq \beta \leq 1$.[10] Cost minimization thus implies $w_M = (1-\beta)\, p\, y_M$ and $w_A = (1-\alpha)\, y_A$. Under these neoclassical assumptions, equation (4) then gives a measure of R, which we label as the Denison–Kuznets reallocation effect:

$$R = ((w_M - w_A)/y) l_M \hat{l}_M \equiv R_{DK}. \tag{5}$$

Comparing equation (5) with equation (3), we can see that R_{SS} and R_{DK} are similar. The difference is that R_{SS} weights labor growth by the difference in average product of labor, $p y_M - y_A$, whereas for R_{DK} the weights are the differences in the value marginal product of labor, or wage rates, $w_M - w_A$.

The two concepts are the same in the limiting case where the production function is a linear function of one factor—in which case the marginal and average products are the same. Thus the shift-share model can be thought of as the growth accounting reallocation effect based on linear production functions with one input, labor. In this sense, it is a special case of the Denison–Kuznets method where $\alpha = \beta = 0$.

3.2. *Interpreting the Reallocation Effects*

Before proceeding, it is useful to note other differences in the interpretation of R_{DK} and R_{SS}. First, consider the standard Solow residual concept, or total factor productivity growth, measured at the aggregate level. This is defined as $TFP \equiv \hat{y} - \gamma \hat{k}$, where γ is the economy-wide capital share. It can also be shown, however, that $TFP = \hat{A} + R_{DK}$, where $\hat{A} \equiv s_M \hat{A}_M + s_A \hat{A}_A$ is the weighted sum of sectoral Hicks neutral productivity growth (see Appendix A.4). Thus the sum of R_{DK} and Hicks neutral productivity growth will exhaust total *TFP*.

Thus R_{DK} satisfies this adding-up condition and, in this sense, R_{DK} is a component of *TFP*, whereas R_{SS} is not. For example, R_{SS} may be positive even if *TFP* is zero.[11]

[10] We use a Cobb–Douglas production function only for analytical convenience. The derivation of R_{DK} holds for neoclassical production functions in general. For an example, see Temple (2001).

[11] This is a simple extension of our earlier point that R_{SS} may be positive even if there is no market distortion so that $w_M = w_A$ (see also Syrquin, 1984). In this case, aggregate TFP growth will be zero despite the fact that $R_{SS} > 0$. One can decompose aggregate *TFP* into R_{SS} and other possible factors—as, for example, Maddison (1987) and Bosworth and Collins (2008) do—but there is no adding-up constraint that ensures that R_{SS} and other productivity growth will exhaust total TFP growth.

In addition, there is considerable ambiguity in the literature as to whether R_{SS} is a labor reallocation effect or a total factor reallocation effect. For example, van Ark (1996), Broadberry (1997), Broadberry and Crafts (2003), and Bosworth and Collins (2008) refer to R_{SS} as measuring the "shift of resources out of agriculture" or a "resource allocation" effect. Cao and Birchenall (2013) use the term "sectoral reallocation effect." However, Maddison (1998), Kuijs and Wang (2006), Brandt *et al*. (2008), Bloom *et al*. (2010), Dekle and Vandenbroucke (2010), McMillan and Rodrik (2011), and de Vries *et al*. (2012) describe their shift-share value, R_{SS}, as capturing "labor reallocation effects." Likewise, recent studies by Roncolato and Kucera (2014), McCaig and Pavcnik (2013), and Ocampo *et al*. (2009) also refer to R_{SS} as measuring labor reallocation effects. This ambiguity highlights the difficulty of ascribing a clear economic interpretation to R_{SS}.[12]

Thus while the Denison–Kuznets effect correctly measures the impact of allocative efficiency gains on the growth rate, it is less clear what R_{SS} measures. In the standard neoclassical setting with competitive markets and constant returns to scale, it can be viewed as an approximation to the actual impact of allocative efficiency improvements based on a linear production function. Similarly, R_{SS} can be seen as a special case of R_{DK} when the production functions are linear in labor, with no other inputs. Hence, although the shift-share method is slightly more parsimonious, insofar as it does not require information or assumptions about the labor cost shares to compute w_M and w_A, this parsimony also imposes limitations in terms of accuracy and creates ambiguity in its interpretation.[13]

4. Quantitative Implications of the Shift-Share Method versus the Denison–Kuznets Method

4.1. *A Simple Rule*

The preceding arguments would be of little consequence if, in fact, R_{SS} and R_{DK} were typically similar, so that R_{SS} was a good approximation for R_{DK}. We therefore now consider how R_{SS} and R_{DK} differ quantitatively.

Using equations (3) and (5), the ratio R_{DK}/R_{SS} can be expressed as

$$R_{DK}/R_{SS}=(1-\beta)-(\beta-\alpha)/(p\,y_M/y_A-1). \tag{6}$$

Inspection of equation (6) shows that if the labor income shares are equal across both sectors, then $R_{DK}/R_{SS}=1-\beta<1$. This particular case of equal factor shares is important since there is some evidence that factor shares across sectors are generally quite similar (Gollin, 2002).

[12] R_{DK} is the partial effect of labor reallocation for a given allocation of capital, whereas the literature suggests that R_{SS} is sometimes interpreted as a total, capital plus labor, factor reallocation effect. As noted above, however, R_{SS} can be non-zero even when all factors are allocated efficiently. Hence it follows that R_{SS} is not, in general, equal to the total factor reallocation effect. For a definition of the total factor reallocation effect, see Appendix A.4.

[13] The shift-share method is nevertheless useful as a decomposition method in other applications where there is no particular theoretical guidance; for example, decomposing inequality into "between" and "within" region effects.

More generally, however, from equation (6), it can also be seen that if (i) the difference in shares $\beta - \alpha$ is small, or (ii) there is a large labor productivity gap, so that $p y_M / y_A$ is large, then $R_{DK}/R_{SS} \approx 1-\beta$. We therefore have the following useful rule of thumb:

Proposition. If the labor cost shares are similar across sectors, or if there is a large labor productivity gap across sectors, then the shift-share reallocation value, R_{SS}, will overstate the growth accounting labor reallocation value, R_{DK}, by a factor of approximately $1/(1-\beta)$, where β is the non-agricultural labor share.

As noted in Figure 4, for China the gap in average labor productivity, $p y_M / y_A$, is large, varying between 6 and 9. Hence if, as the evidence suggests for China, $0.4 \leq 1-\beta \leq 0.6$, then R_{SS} will overestimate the TFP gains from labor reallocation by approximately 1.66 to 2.5 times.

4.2. *Base Data*

To obtain a more accurate estimate, we proceed by computing both R_{SS} and R_{DK}. We require Chinese data on sectoral outputs, sectoral factor inputs, factor shares, and GDP.

Factor share data are taken from Bai and Qian (2010), and are based on provincial GDP data from Hsueh and Li (1999) and the National Bureau of Statistics of China (2007). Bai and Qian (2010) find an average labor share of $1-\beta=0.47$ for non-agriculture.[14]

For agricultural labor shares, Bai and Qian (2010) report a value of $1-\alpha=0.89$, but acknowledge that this is overestimated since it includes land income. Cao and Birchenall (2013) therefore propose an adjustment which reduces this value from 0.89 to 0.38. In what follows, we therefore choose a parsimonious value of $1-\alpha=2/3$, as a base case, and also experiment with $1-\alpha=0.89$ and $1-\alpha=0.38$. As implied by the preceding Proposition, however, the results are very insensitive to changes within this range.

These values are also similar to other values reported in the literature. For example, for agriculture and non-agriculture respectively, the labor shares are 0.5 and 0.6 over 1978–2004 in Bosworth and Collins (2008), 0.5 and 0.5 over 1978–2008 in Brandt *et al*. (2008), and 0.76 and 0.46 over 1978–2003 in Dekle and Vandenbroucke (2010, 2012). An exception is Chow (1993), who obtains a much smaller value of 0.32 for agriculture over 1952–88 using a production function estimation. Using alternative labor shares affects the results in predictable ways based on equation (6) and does not affect our conclusions significantly.[15]

For output, we use the sectoral value added data from Bosworth and Collins (2008) for 1978–2004. This is updated to 2011 using data from the China Statistics Yearbook (hereafter CSY).[16] Hence, we use the official GDP deflator from the

[14] This is also very close to the value found by Young (2003), based on data from national accounts and input–output tables.

[15] These alternative values are given in Appendix A.6.

[16] Bosworth and Collins (2008) divide the economy into three sectors: agriculture, industry, and services. For ease of comparison with other studies, we aggregate industry and services into the "non-agriculture" sector. Nevertheless, we obtain the same reallocation as Bosworth and Collins (2008), to two decimal places, when using the same data and shift-share methodology.

CSY for the agriculture and the ex-factory industry price index from the CSY as the deflator for the industry sector.

The capital stock estimates are calculated from the gross fixed capital formation drawn from various issues of the CSY. Following Young (2003), we use the official investment deflator taken from the World Development Indicators database. We use the capital–output ratio and assumed depreciation rate (6 percent) from Young (2003). The resulting aggregate capital stock data are in line with existing estimates, such as those of Wang and Yao (2003) and Chow and Li (2002).

The sectoral capital shares for 1978–95 are taken from Hsueh and Li (1999). For 1996–2011, we use investment in fixed asset shares by the three main sectors from the CSY.

Finally, sectoral employment data are obtained from Bosworth and Collins (2008). Specifically, for 1978–2002 we sum employment over sub-sectors from various issues of the CSY to obtain agricultural and non-agricultural employment, instead of relying on pre-summed totals. Sub-sector splits are not available after 2002, so we use the employment shares of the three main sectors from various issues of the CSY, and multiply by total employment to obtain employment in agriculture, industry, and services.[17]

4.3. *Alternative Data Sources*

The base data described above are very standard. Nevertheless, there are also many well-known issues with Chinese data and there is a large literature on revised and corrected macroeconomic aggregates. To that end, we have also conducted an extensive sensitivity analysis using some of these alternative data sets. These alternatives and additional results are detailed in Appendix A.6. However, we also briefly comment here on some of the sources and motives for data revisions.

First, it is often claimed that Chinese real GDP growth is overestimated due to firms' incentives for upward reporting bias and the reporting system itself (Woo 1998). This issue has been addressed by Bosworth and Collins (2008) and Young (2003) by using alternative price indices. A second way to overcome this bias is to develop a physical output index, as proposed by Wu (2002, 2011). Thus we also report the results using the real output series of Wu (2011) in Appendix A.6.

With respect to capital, Holz (2006b) has constructed an index based on asset scrap rates instead of a depreciation rate. This series exhibits a lower growth rate in the mid-1990s.[18] Similarly, Wang and Szirmai (2012) report capital stocks based on age–efficiency profiles instead of age–price profiles. These show a higher growth rate, since 1980, than the existing estimates. Again, we report the results for these alternatives in Appendix A.6.

[17]Note that the pre-summed total employment or employment by the three main sectors from the CSY have been revised in accordance to the population censuses since 1997; they are not necessarily close to the sum of sub-sectoral employment data from administrative reporting system. Therefore, the magnitude of the 1997 downward revision was factored to obtain a new pre-summed employment figure for the years after 2002.

[18]His estimates also address several other shortcomings associated with most previous estimates, particularly with respect to the choice of investment data.

Finally, Holz (2006a) and Brandt *et al*. (2008) have pointed to problems with Chinese employment data due to the treatment of laid-off workers, undocumented off-farm migration, and non-farm rural self-employment. To address these concerns, we use data from these sources as well. In addition, we also allow for floating migrants following Bulman and Kraay (2011). Lastly, we also consider the data set from Wu (2011), which adds military personnel to non-productive service employment. Again, these results are given in Appendix A.6.

4.4. *Quantitative Results*

Growth Accounting Results

Before discussing the actual reallocation effects, it is useful to first consider the overall growth accounting results, in order to give some context and provide a point of comparison with other studies.

To that end, Table 2 gives a summary of the standard growth accounting results for each sector and the aggregate economy. Notably, due to massive rural–urban migration, the annual growth rate of employment in the non-agriculture sector (4.03 percent) is much higher than the agricultural sector (–0.59 percent). This is also reflected in a significant increase in the non-agricultural employment share from 0.29 to 0.65 over 1978–2011 (see also Figure 1). Accompanying this massive labor reallocation, is also rapid capital accumulation at the sectoral and aggregate level.

The decomposition of per worker GDP reveals that the contribution of capital accumulation is 4.91 percentage points per year, out of 8.12 percentage points per year of GDP growth per worker. Thus, capital accumulation plays an important role in China's labor productivity growth.

Although nearly all (95 percent) of the capital is in non-agriculture, it can be seen that the annual growth rates of capital in each sector are relatively similar. Thus, although the agricultural sector has only 5 percent of the economy's capital, agricultural capital has grown fast enough to maintain a constant share over time.[19] Hence, despite the importance of aggregate capital accumulation, the sectoral reallocation effects in China have been dominated by labor movements.

Finally, we find that TFP growth is also important, accounting for 3.05 percentage points per year overall, with a slightly higher growth rate in non-agriculture than agriculture.[20]

Reallocation Effects

These growth accounting data give a picture of China's growth that is very consistent with the existing literature, but our focus is on the reallocation effects. The results for the reallocation effects using the shift-share method, R_{SS}, and the Denison–Kuznets method, R_{DK}, are given in Table 3. For reference, columns (1)–(3) report

[19]Consequently, the capital reallocation effects are very small. We find a value of 0.03 percentage points per year over 1978–2011. The capital reallocation effect is discussed further in Appendix A.4.

[20]This is a broad definition of TFP growth that includes the reallocation effects discussed below as well as any human capital accumulation and unmeasured inputs.

TABLE 2

Growth Accounting Results (% per Year)

	Total Economy	Agriculture	Non-agriculture
Annual growth (1978–2011):			
GDP, Y	9.81	4.56	10.72
Capital, K	11.37	9.64	11.45
Employment, L	1.56	−0.59	4.03
Per worker capital, k	9.67	10.30	7.13
Per worker GDP, y	8.12	5.19	6.43
Contribution to per worker GDP growth from:			
Per worker capital, k	4.91	3.32	3.72
TFP	3.05	1.82	2.60
Shares/ratios:			
		Year 1978	Year 2011
Employment in non-agriculture, L_m/L		0.29	0.65
Capital in non-agriculture, K_m/K		0.95	0.97
GDP in non-agriculture, $p\,Y_m/Y$		0.72	0.94
Capital intensity ratio, k_m/k_a		44	17
Labor productivity ratio, $p\,y_m/y_a$		6	9

Note: Following Solow (1957), the TFP growth is defined as a residual from $\hat{y}$ and the contribution of per worker capital; hence it is a broad definition of TFP growth that includes the reallocation effects as well as any human capital accumulation and unmeasured inputs. The size of aggregate TFP growth, however, is not the focus of this paper.

GDP per worker growth, the capital contribution, and the TFP contribution for the relevant sub-periods. By construction, column (1) is the sum of columns (2) and (3).

The shift-share reallocation effect, R_{SS}, from equation (3) is given in column (4). It can be seen that, for the period 1978–2011, $R_{SS} = 1.76$ percentage points per year.[21] Likewise, R_{SS} varies from 1.17 percentage points per year in 1991–2001 to 2.46 percentage points per year in 2001–11.

Thus these figures might be interpreted as implying that reallocation effects account for a relatively large fraction of growth. For example, for 1978–2011, R_{SS} is 1.76 percentage points per year, compared to GDP per worker growth of 8.12 percentage points per year and a TFP growth rate value of 3.05 percentage points per year.

The Denison–Kuznets growth accounting results, R_{DK} from equation (5), are shown in column (5) of Table 3. It can be seen that the value of R_{DK} for 1978–2011 is 0.77 percentage points per year, which is significantly less than $R_{SS} = 1.76$ percentage points per year. Likewise, comparing columns (4) and (5) over each sub-period, the value of R_{DK} is much smaller than R_{SS}, and it is easy to verify that R_{SS} is around 2.3 times larger than R_{DK} in each sub-period.[22]

[21]The reported value is the simple average of the values over the relevant period. Our values do not correspond exactly with those reported by Bosworth and Collins (2008), since for simplicity we aggregate the data to just two sectors, whereas Bosworth and Collins use three sectors. However, for the same time periods our results are very close to theirs. For example, we find R_{SS}= 1.8 percentage points per year for 1978–93, which corresponds to the value of 1.7 percentage points per year reported by Bosworth and Collins (2008).

[22]The results for R_{DK} change very little when alternative labor shares in agriculture are used. If the labor share in agriculture is 0.89 or 0.38, then R_{DK} becomes 0.71 and 0.85 percentage points per year, respectively, over 1978–2011. In terms of sensitivity in response to alternative data sources, R_{DK} ranges from 0.59 (1978–2008) to 0.92 (1978–2011) percentage points per year (see Appendix A.6). The ratio R_{DK}/R_{SS}, however, remains fairly constant at around 0.43–0.44.

TABLE 3
Growth and Reallocation Effects (% per Year)

	(1) GDP per Worker	(2) Contribution of k	(3) TFP	(4) Shift-Share	(5) Denison–Kuznets	(6) Shift-Share with Human Capital	(7) Denison–Kuznets with Human Capital
	$\hat{y}$	$\gamma\hat{k}$	$\hat{y}-\gamma\hat{k}$	R_{SS}	R_{DK}	R_{SS}^{H}	R_{DK}^{H}
1978–2011	8.12	4.91	3.05	1.76	0.77	0.66	0.25
1978–91	5.24	2.96	2.20	1.51	0.65	0.56	0.20
1991–2001	9.27	5.51	3.54	1.17	0.51	0.46	0.17
2001–11	10.81	6.87	3.76	2.46	1.09	0.92	0.37

Note: Following Solow (1957), the TFP growth is defined as a residual from $\hat{y}$ and the contribution of per worker capita $\gamma\hat{k}$ (where γ is the capital income share at the aggregate level); thus it is a broad definition of TFP growth that includes the reallocation effects as well as any human capital accumulation and unmeasured inputs. With data on per worker human capital from Li (2014), the contribution of human capital accumulation, $(1-\gamma)\hat{h}$, is estimated at a value of 2.46 percentage points per year for period 1978–2011, and 1.21, 1.40, and 5.21 percentage points for each subperiod. If we define the TFP growth as a concept net of the contribution from human capital accumulation and denote it as TFP^{H}, then the comparable ratio R_{DK}^{H}/TFP^{H} over 1978–2011 is 0.42.

These estimates therefore confirm the Proposition, that the shift-share method significantly overstates the impact of labor reallocation on growth in this neoclassical setting.

Thus we have shown that the vast majority of studies on growth and labor reallocation in China have used the shift-share method as opposed to the Denison–Kuznets method. Second, we have shown that, with competitive markets and constant returns to scale, the Denison–Kuznets method is a preferred measure of the labor reallocation effect. Third, we have now also shown, both analytically and numerically, that the shift-share method significantly overstates the growth effects of labor reallocation in China.

Consequently, we reach a preliminary conclusion that most of the existing literature on China's growth and labor reallocation has overstated the quantitative impact of labor reallocation on China's TFP growth by a factor of around 2.3 times. Application of the Denison–Kuznets method, with a standard data set, suggests that labor reallocation has contributed 0.77 percentage points per year to China's growth. This compares with a TFP growth of 3.05 percentage points per year and a per worker GDP growth rate of 8.1 percentage points per year. Thus conventional growth accounting, with standard data and factor shares, indicates that labor reallocation effects have been quite small.

5. Human Capital

The literature cited above implicitly assumes that differences in the marginal, or average, product of labor across sectors is evidence of inefficient factor allocation. Nevertheless, there may be many reasons why the marginal product of labor may not be equated across sectors in equilibrium. This includes differences in living costs, transport, and migration costs. Similarly, there may be unmeasured differences in human capital across sectors.

These factors are typically ignored because they are difficult to measure. Nevertheless, Li (2014) have recently compiled data on human capital levels across sectors based on the standard Mincerian concept of human capital.[23] It is therefore interesting to consider the extent to which differences in the average level of human capital might further adjust the gains from labor reallocation.

Figure 5 thus shows the ratio of the level of human capital across urban and rural sectors in China based on Li (2014). It can be seen that in the 1980s, the urban sector had approximately twice as much human capital per worker than the rural sector, and that this ratio rises gradually through time, to about 2.5 times. The growth in the ratio is a significant achievement, given that there is also rapid rural–urban migration at this time.

While this rural–urban distinction is not identical to our agriculture and non-agriculture division, there is likely to be considerable overlap, and we therefore proceed under the assumption that the rural–urban data on human capital will reflect human capital levels of labor employed in agriculture and non-agriculture. Then we can define the total supply of labor services to non-agriculture and agriculture to be $H_M \equiv h_M L_M$ and $H_A \equiv h_A L_A$, where h_M and h_A are the sectoral levels of human capital per worker taken from Li (2014).

Figure 6 then compares the labor productivity data, $py_M = p\,Y_M/L_M$ and $y_A = Y_A/L_A$, with productivity per effective unit of labor, $p\,Y_M/H_M = py_M/h_M$ and $Y_A/H_A = y_A/h_A$. As expected, the gap in output per effective worker is much smaller than that of output per worker. Skill-adjusted productivity, or output per effective worker, is around 3–4 times higher in non-agriculture. This is approximately half the gap in output per worker of 6–9 times. This magnitude of adjustment for human capital differences across sectors is very similar to those reported by Gollin *et al*. (2014) across a number of countries. It suggests that the labor reallocation effects derived above overstate the actual gains since they overstate the actual difference in labor productivity between sectors.

5.1. *Growth Accounting with Human Capital*

In order to see the implications of sectoral human capital differences for the measurement of the Denison–Kuznets reallocation effect, suppose that workers all supply one unit of labor time inelastically and differ in only their skill level, h_i. The aggregate production functions in each sector are then $y_M = A_M k_M^{\beta} h_M^{1-\beta}$ and $y_A = A_A k_A^{\alpha} h_A^{1-\alpha}$. The value of the marginal product of a unit of effective labor in non-agriculture is $w_M^e = (1-\beta)(p\,y_M/h_M)$ and the wage per effective worker in agriculture is $w_A^e = (1-\alpha)(y_A/h_A)$. Hence the wage rates per unit of time for a worker providing a level of service h_i are, respectively, $h_i\, w_M^e$ and $h_i\, w_A^e$.

[23]Note, however, that Li (2014) distinguishes between rural and urban sectors, instead of agriculture and non-agriculture. This represents a potential limitation of our data. Also, data on real human capital per worker by sector (rural and urban) are available for 1985–2010; thus data over 1978–84 and 2011 are derived based on mean growth of real human capital per worker over 1985–90 and 2005–10, respectively.

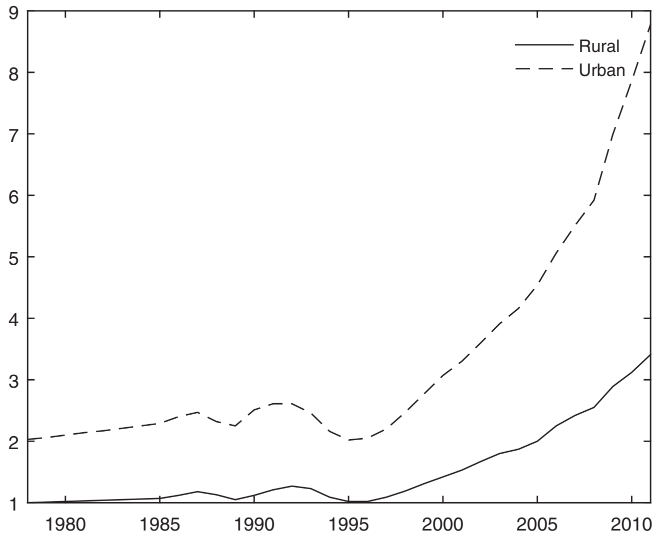

Figure 5. Real Human Capital per Worker, Indexed by Sector in China (1978–2011)
Note: For data sources, see Section 4.2.

Labor market clearing requires that the wage rate is the same for workers with the same skill level, which therefore requires that the wage per efficiency unit is equated across both sectors, $w_A^e = w_M^e$. Hence, even in an efficient market with no misallocation, there will exist an apparent wage gap of $w_M - w_A = (h_M - h_A)w^e > 0$ between sectors, which simply reflects the fact that skill levels differ across each sector.

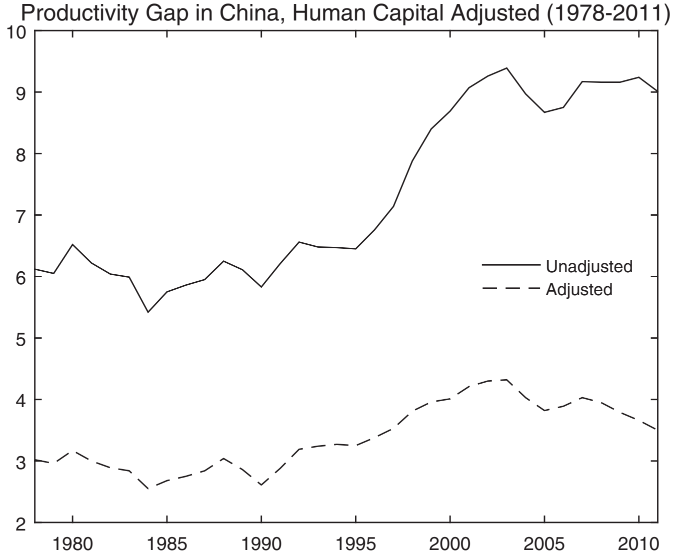

Figure 6. The Productivity Gap in China, Human Capital Adjusted (1978–2011)
Note: For data sources, see Section 4.2.

Intuitively, the reallocation effect should depend on the gap $w_M^e - w_A^e$ and the difference in human capital levels. Thus, as shown in Appendix A.2, the Denison–Kuznets reallocation effect is now

$$R_{DK}^H = ((w_M^e - w_A^e)/y^e)(h_i/h_M)l_M^e \hat{l}_M, \tag{7}$$

where $l_M^e \equiv H_M/(H_M + H_A)$ and h_i is the skill level of the migrant. A similar human capital adjustment can also be applied to the shift-share methodology (see Appendix A.3).

It can be seen that equation (7) differs from equation (5) in two main respects. First, as expected, the reallocation effect depends on the wage gap in terms of efficiency units. The higher level of human capital per worker in non-agriculture means that $(w_M^e - w_A^e)/y^e < (w_M - w_A)/y$; so, other things being equal, we expect $R_{DK}^H < R_{DK}$.

Second, the reallocation effect contains the term h_i/h_M, which reflects the impact of the movement of skills on each sector's average human capital level. For example, suppose that migrants from agriculture have the same skill level as the agricultural average, so that $h_i = h_A$ and so $h_i/h_M < 1$. In this case, this term also reduces the size of R_{DK}^H and this can be thought of as the impact of migrants diluting average human capital per worker in non-agriculture. If $h_i < h_A$, then this will further reduce R_{DK}^H. Alternatively, if migrants have the same level of human capital as modern sector workers, then $h_i/h_M = 1$. Even in this case, therefore, overall we still expect $R_{DK}^H < R_{DK}$.

Li (2014) does not provide evidence on migrants' human capital levels. Nevertheless, evidence in Sicular *et al*. (2007) suggests that migrants' human capital levels in China are significantly lower than the average in the urban sector, and very close to the rural average. Thus the human capital adjusted reallocation effects R_{SS}^H and R_{DK}^H are given in columns (6) and (7) of Table 3 for the case $h_i = h_A$. The implications of alternative assumptions, along with some evidence on the skill level of migrants in China, are given in Appendix A.5.

It can be seen that the adjustment for sectoral differences in human capital also results in a significant downward adjustment in the size of the labor reallocation effect. Over 1978–2011, the Denison–Kuznets measure is reduced from 0.77 percentage points per year to 0.25 percentage points.[24] In each sub-period, the adjustments to R_{SS}^H and R_{DK}^H are of similar magnitude. Likewise, allowing for human capital differences across sectors reduces the shift-share measure from 1.76 percentage points per year to just 0.66 percentage points per year.

5.2. *Combined Impact*

We now summarize the total impact of all adjustments by comparing the values obtained from the shift-share analysis, R_{SS} in column (4) of Table 3, with our preferred measure, R_{DK}^H in column (5).

[24] R_{DK}^H using alternative data sources varies from 0.13 percentage points per year to 0.25 percentage points per year, for the period 1978–2011.

It can be seen that the total effect is substantial. Over the entire period 1978–2011, moving from the shift-share method to the more appropriate Denison–Kuznets method, and allowing for human capital differences across sectors, the value of the "reallocation effect" falls from 1.76 percentage points per year to just 0.25 percentage points per year.

Thus, on the one hand, we have the conventional figure of around 1.76 percentage points per year as a measure of the gains from labor reallocation in China. But using the more appropriate Denison–Kuznets method, and allowing for the difference in labor quality across sectors, reduces the contribution of labor reallocation to 0.25 percentage points per year, making it a relatively minor component of growth. The pattern is similar across each period, and we find that the human capital adjusted Denison–Kuznets labor reallocation effects are always quite small relative to per worker GDP growth.

6. Discussion

Our results thus suggest that the conventional view—that labor reallocation has made a major contribution to China's growth—is not readily justified by standard growth accounting analysis. A reallocation effect of 0.25 percentage points per year is very small relative to China's overall growth and is much smaller than the conventional view in the literature of 1–2 percentage points per year.[25]

This conclusion may seem surprising given the historical importance of structural change in development theory, and the extensive literature on labor reallocation and growth in China. Hence it is important to note some caveats.

First, there are clearly a number of reliability or quality issues with Chinese data. In particular, the human capital data should be viewed as indicative only. But, more broadly, there is significant room for improvement for most of the macroeconomic data. We have tried to minimize this uncertainty by showing that the results are not very sensitive to the use of alternative data on employment, capital, output, and labor shares.

In addition, our results are clearly conditional upon the framework in which they are derived—the neoclassical production model with competitive markets and constant returns to scale. Under these assumptions, the Denison–Kuznets reallocation effect is the correct measure of the gains from labor reallocation and the shift-share method can be seen as an approximation based on a linear production function.

This gives a clear basis for preferring the Denison–Kuznets measure of reallocation effects. Nevertheless, it is possible that the neoclassical model does not capture all of the relevant links between labor reallocation and growth.

6.1. *Externalities, Economies of Scale, and Surplus Labor*

Many models of structural change are based on explicit assumptions about economies of scale in the modern sector, or externalities associated with public

[25]Moreover, it is also possible that our estimates, though very small, overstate the gains from labor reallocation, since we have not taken into account differences in prices across urban and rural regions. Some estimates of these differences are given by Sicular *et al*. (2007).

goods. Both imply additional direct links between labor reallocation and productivity that are not considered in the standard growth accounting framework.

Likewise, the standard Denison–Kuznets growth accounting approach assumes that all factors are fully employed and valued at their marginal products. Hence it excludes a class of "surplus labor" arguments that are sometimes used to motivate a sectoral gap in the marginal product of labor. Denison–Kuznets growth accounting does incorporate surplus labor to the extent that agricultural labor can be earning a wage less than the value of its marginal product in the non-agricultural sector. Nevertheless, some surplus labor arguments imply additional consequences of labor reallocation on growth by reducing underemployment.[26]

Thus inter-sectoral labor reallocation may affect growth in other ways, beyond the standard allocative efficiency gains, which are not captured by the Denison–Kuznets reallocation effect. Nevertheless, in this case, neither the shift-share method nor the Denison–Kuznets method is necessarily the most appropriate method.[27]

6.2. *Capital Accumulation*

Another consideration relates to the interaction between reallocation effects and capital accumulation. Specifically, in a neoclassical growth model, where capital accumulation is endogenous, an improvement in allocative efficiency will induce capital accumulation.[28]

It is also useful to know how much extra growth is generated by these induced capital accumulation effects from labor reallocation. Nevertheless, this requires an explicit theory of capital accumulation. Because of this, the induced capital accumulation effects can only be decomposed using calibrated growth models that specify an explicit mechanism for capital accumulation.[29]

Thus, although we find that the effect of labor reallocation on China's growth, due to improvements in allocative efficiency, is small, this does not mean that structural change is unimportant in China's growth. But the results do suggest that this particular link between agricultural labor reallocation, allocative efficiency and growth, has been far less significant in China than much of the literature suggests.

Specifically, as noted above, many studies view the slowing of rural–urban migration as a significant cause of China's growth slowdown (Gong *et al.*, 2009;

[26]Surplus labor theories build on traditional models of Lewis (1954), Ranis and Fei (1961), and Harris and Todaro (1970). As noted above, however, the evidence for surplus labor is very mixed and in the case of China, the gap can be seen purely as a consequence of the Hukou system.

[27]For examples of modified "shift-share" analyses that take into account increasing returns to scale and surplus labor, see Timmer and Szirmai (2000) and van Ark and Timmer (2003).

[28]Specifically, in a standard Ramsey model, an improvement in output per effective input will generate an increase in capital equal to the inverse of the aggregate labor share of output. See, for example, Klenow and Rodriguez-Clare (1997) and Robertson (2000) on the impact of productivity on capital accumulation, and Robertson (1999) and Landon-Lane and Robertson (2009) on the impact of reallocation on capital accumulation.

[29]For an example with respect to China, see Ye (2015). Since we have found that the reallocation effects are a minor component of per worker GDP growth, in a neoclassical growth model they would also be a relatively minor contributor to capital accumulation. As a rule of thumb if, as in China, the capital share is approximately 0.5, then any given improvement in allocative efficiency will have double the impact on the level of per worker GDP from one steady state to the next, due to induced capital accumulation.

Zhu, 2012) and this is also a widely held view in the policy literature (*The Economist*, 2013; Krugman, 2013). Likewise, there is a significant literature that emphasizes internal migration and factor accumulation, as opposed to productivity growth, as the main sources of growth in the successful Asian economies including China (Krugman, 1994; Young, 1995, 2003). Since we find that China's high growth has not relied on large gains from allocative efficiency, our results cast some doubt on the relevance of this perspective for China, and possibly for other countries as well.[30]

7. Conclusion

Seemingly small differences in per capita income growth rates have very large consequences for living standards. Thus it is important to be as accurate as possible when investigating the sources of growth. To that end, the standard framework for decomposing growth, dating back to Solow (1957), Kuznets (1961), and Denison (1967), divides growth into factor accumulation and TFP, including reallocation effects. If markets are competitive and there are constant returns to scale, then this Denison–Kuznets method is the correct measure of the impact of labor reallocation on growth. In particular, it satisfies an adding-up condition such that the value share weighted growth of factor inputs, reallocation effects, and technological progress exhaust total output growth.

Most of the literature on reallocation effects in China (11 out of 16 studies) has, however, used an alternative "shift-share" method, which does not satisfy these adding-up properties, but can be interpreted as an approximation to the Denison–Kuznets labor reallocation effect based on linear production functions.

We compare the two approaches and show that the shift-share method produces reallocation effects that are larger than the Denison–Kuznets measure by a factor of, approximately, $1/(1-\beta)$, where $1-\beta$ is the labor income share in non-agriculture. We then show further that, for a range of Chinese data sets, the shift-share reallocation effects are more than twice as large as the Denison–Kuznets labor reallocation effects.

Second, we use recent data on rural–urban human capital differences to improve the measurement of misallocation effects. Specifically, since the measured wage differences across sectors are affected by differences in the average level of human capital, we use the sectoral human capital levels to infer the efficiency wage gap across sectors. Since human capital per worker is much higher in non-agriculture, this also leads to a significant downward adjustment in the size of the estimated gains from labor reallocation.

Together, these two adjustments lead to a very substantial revision of the role of sectoral labor reallocation in China's growth, from 1.76 percentage points per year over the period 1978–2011 to just 0.25 percentage points per year. This

[30]In this context, it is interesting to note that our more modest estimates of labor reallocation effects in China are not dissimilar from estimates used in assessing the historical sources of growth in Europe, using the Denison–Kuznets method. Specifically, labor reallocation in Europe appears to have accounted for only 1/20th to 1/7th of annual growth in GDP per worker Temple (2001). This is similar to our estimates of 0.77 percentage points per year, which represents just under 1/10th of GDP per worker growth in China, before any adjustment for human capital.

represents a small fraction of China's growth. As such, our results cast doubt on the importance of allocative efficiency gains from labor reallocation in China's economic miracle. This observation also has implications for contemporary policy—particularly for understanding China's growth prospects as rural–urban migration slows, and for understanding how other countries might replicate China's growth miracle.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix A.1: Labor Reallocation Effects R_{SS} and R_{DK}.
Appendix A.2: Denison–Kuznets Labor Reallocation Effects with Human Capital.
Appendix A.3: Shift-Share Labor Reallocation Effects with Human Capital.
Appendix A.4: The Growth Accounting Approach to Total Reallocation Effects.
Appendix A.5: Labor Heterogeneity.
Table A.1: Alternative Values of R_{DK}^{H} With Heterogeneity of Agricultural Labor (% per Year).
Appendix A.6: Robustness Check with Alternative Data Sources.
Table A.2: Growth and Reallocation Effects with Alternative Data Sources (% per Year).