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STRUCTURAL TRANSFORMATION AND ALLOCATION EFFICIENCY IN CHINA AND INDIA

by Enrica Di Stefano* and Daniela Marconi*

Abstract

Market frictions prevent the efficient allocation of factors of production, slow down structural transformation and lead to costs in terms of lower output and aggregate total factor productivity (TFP). We use a theoretical framework developed by Aoki (2012) featuring sector-specific frictions on capital and labor *à la* Chari, Kehoe and McGrattan (2007), and compute capital and labor misallocations in China and India using data for 26 sectors over the period 1980-2010. Our findings show that large factor misallocations exist in the two countries. We estimate the potential gains in terms of aggregate TFP stemming from an efficient allocation of factors to range from 25% to 35% in China and from 35% to 40% in India. Finally, we discuss the implications for structural transformation and the relationship between the observed allocation inefficiencies and the evolution of the business environment in the two countries.

JEL Classification: E23, O11, O41, O47, O53, O57.
Keywords: structural transformation, frictions, resource allocation, productivity, China, India.

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* Bank of Italy, Directorate General for Economics, Statistics and Research.

1 Introduction

Technological progress and structural transformation are key drivers of economic growth. These two drivers interact with each other and are both influenced by the institutional and organizational setup of the economy. On the one hand, aggregate total factor productivity (TFP) depends on the structure of the economy; on the other, institutions and organizational setup are key drivers of the development of the economic structure. When resources are allowed to redistribute promptly to take advantage of changing patterns of productivity and technological progress, then structural transformation fuels economic growth (Kuznets, 1973; Acemoglu, 2008). Market frictions may prevent the efficient allocation of production factors, slowing down structural transformation and undermining aggregate TFP. Frictions may arise from policy-induced price distortions, non-competitive market structures, credit and financial market frictions, labor market legislation and regulation.

In this paper we analyze China's and India's structural transformations. Over the thirty-year period to 2010, there has been a notable shift of surplus labor out of the primary sector toward more productive sectors. Labor reallocation, together with capital deepening, has resulted in profound changes in output composition and in faster economic growth. However, the observed reallocations of factors and the changes in value added shares across sectors in both countries cannot be fully reconciled with the predictions of more traditional models of unbalanced growth, such as Acemoglu and Guerrieri (2008), unless incorporating frictions that impede the optimal allocation of resources across sectors (on this point see Buera and Kaboski, 2009).

There is growing attention in the literature to the role of factor misallocation in explaining aggregate TFP differences across countries. A consensus is emerging around the view that TFP gaps may result not only from lack of resources or from slow technological diffusion/adoption but also from the inefficient functioning of technology (Banerjee and Moll, 2010; Restuccia and Rogerson, 2013). The misallocation literature mainly focuses on within-industry distortions. In the presence of heterogeneous firms, aggregate industry TFP depends not only on the productivity of individual production units but also on how inputs are allocated across these units. If the marginal products of capital and labor are not equalized across units, then there is misallocation. The dispersion of marginal products across firms

is a measure of idiosyncratic distortions that impede more productive firms to reach their optimal size and scale of production. The literature points to the existence of large inefficiencies in factor allocations between firms, particularly in emerging and transition countries (Restuccia and Rogerson, 2013; Hsieh and Klenow, 2009; Gamberoni *et al.* 2016; Leòn-Ledesma, 2016).

The evidence available for China and India shows that potential gains from reallocating resources across firms and subnational regions are considerable. Hsieh and Klenow (2009), for instance, estimate large dispersions of marginal productivity across manufacturing firms both in China and India; they show that if the distortions were reduced to the levels of the United States, manufacturing TFP would increase by 30%-50% in China and by 40%-60% in India. Using a similar framwork, Brandt *et al.* (2013) examine labor and capital misallocations across provinces in China and between state and non-state sectors and find that misallocation between and within provinces resulted in a reduction of non-agricultural TFP of at least 20%. Adopting a more empirical approach, Duranton *et al.* (2015) evaluate factor misallocations within the manufacturing sector and between districts in India and find that just moving from a median level of misallocation to the top decile is associated with a 50% increase in output per worker in the formal sector.

Less explored is the link between misallocation and structural transformation. The issue is of utmost importance in developing countries where resource reallocation is still a key driver of structural transformation and aggregate productivity growth. A very recent contribution in this strand of literature is given by Cheremukhin *et al.*, 2015. Within a two-sector growth model, they show that the changes in the intersectoral labor wedge in China play the dominant role in accounting for the change in the share of labor force in agriculture and that TFP growth and changes in the intersectoral labor wedges are the two most significant factors contributing to China's GDP growth over the period 1978-2012. As we will argue later on, our results are consistent with this finding.

We contribute to the literature by exploring the nexus between factor misallocations and structural transformation in China and India. Specifically, we assess the degree of misallocations of labor and capital across industries and over time using an approach that, so far, has been applied only to advanced countries (*e.g.*, Aoki, 2012; Dabla-Norris *et al.* 2015). To assess the degree of factor misallocation

across sectors, we follow Aoki (2012) and propose a multi-sector model with sector-specific frictions. Such frictions, or wedges, were originally proposed by Chari, Kehoe and McGrattan (2007) and take the form of taxes on the price of the production inputs. The sector-specific wedges as synthetic indicators of *any* deviation from the frictionless benchmark of perfect competition. With this methodology to hand, we measure the degree of capital and labor misallocation across 26 sectors for China and India and we compute the cost in terms of losses in aggregate TFP in the period 1980-2010. Our counterfactual experiment is to calculate aggregate value added under the assumption of no frictions and compare it with the actual value added as observed in the data. We concentrate on industry-level value added in order to have a direct comparison with GDP. We acknowledge the importance of considering also the role of intermediate inputs, as they may be important sources of distortions, particularly in countries such as China and India (Jones, 2013). However, while it is more immediate to map within-industry input distortions to misallocations across heterogeneous production units, we deem by far less intuitive to do so when considering between-sectors distortions, since intermediate inputs are likely to be more than any other inputs industry specific.[1]

In this context we address four questions. First, how large are factor misallocations in China and India? Second, have they changed over time? Third, what are the implied costs in terms of aggregate TFP losses? And finally, what are the implications in terms of structural transformation? We show that capital and labor misallocations are very large in both China and India, but with country-and-time-specific patterns. Over time the allocation efficiency of labor displays little or no improvements in India, whereas in China it improved significantly after 2000, driven by agriculture. In China the allocation of capital worsened since 1995, with distortions peaking in 2005, while in India misallocation of capital remained persistently high. In both countries, the contribution of capital misallocation to overall misallocation has been increasing over time, since 1995. We estimate that if capital and labor were reallocated efficiently, aggregate TFP could be raised by 25% to 35% in China and by 35% to 40% in India in 2010. Furthermore, we show that, by comparison, within this framework, distortions in the US appear to be very small. Results are ro-

[1]Land allocation is also a topic issue in emerging countries (Adamapoulos *et al.* 2016; Duranton *et al.*, 2015), however sector specificity and immobility makes it very difficult to provide an intuitive argumentation in favor of land reallocation across industries.

bust to alternative choices of labor and capital intensities. Moreover, our analysis confirms that misallocations in China and India reflect country-specific structural impediments, namely, thereby confirming that reform priorities differ across the two countries. In China reforms should address the low productivity of the tertiary sector and should aim at removing capital market distortions. In India, reforms should aim at improving the productivity of the secondary sector and focus on the labor market functioning and human capital formation.

In this paper we do not attempt to assess the relative importance of specific underlying sources of misallocation; rather according to our approach, any factor that induces misallocation generates wedges in the first-order conditions of firms' optimization problems. Based on the definition provided by Restuccia and Rogerson (2013), our approach falls into the category 'indirect' approach, as opposed to the 'direct' approach, which aims instead to identify the sources of misallocation. Nonetheless, we show that even within a very simple set up it is possible to obtain results that can be interpreted in light of country-specific features in terms of evolution of the business environment, factor market regulations and institutional context.

The paper is structured as follows: the next section briefly presents the main stylized facts describing the structural transformation of China and India; section 3 presents the theoretical framework. In section 4, we provide evidence on the existence of factor misallocations in the two economies and assess the departures from a benchmark of perfect competition in the allocation of capital and labor across sectors. Then, we measure the implied losses in terms of aggregate TFP. Finally, section 5 discusses implications for structural transformation and relates findings to country-specific features in terms of evolution of the business environment, factor market regulations and institutional context; the last section concludes.

2 Facts

Structural transformation in China and India has followed the established regularities of structural transformations in developing economies.

1. The composition of output has changed dramatically over the 30-year period 1980-2010: in nominal terms, the drop in the share of total value added accounted for by the primary sector was matched by an almost equal increase in the share accounted for

by the tertiary sector, while the secondary sector grew approximately in line with total value added. Changes in the composition of output reflect the evolution of households' consumption baskets (Table 1).

2. The portion of (quality-adjusted) labor allocated to each sector changed in the same direction of value added shares, while the drop in agriculture was matched by an almost equal increase in the tertiary sector. By contrast, the relative weight of each sector in terms of capital did not always move in the same direction. In India, the portion of capital absorbed by the tertiary sector declined slightly, amid a strong increase in the absorption of labor. In China, it was the secondary sector that experienced a decline in the share of total capital, against a slight increase in the share of labor (Table 2).

3. Capital deepening increased threefold in India and eleven-fold in China over the thirty-year period to 2010. In both countries, capital deepening (adjusted for labor and capital quality) was faster in agriculture and in the secondary sector, compared to the tertiary sector (Table 2).

3 The Aoki multi-sector model of factor allocation

This section describes the theoretical framework we use to assess factors misallocation in China and India. We adopt a multi-sector model that allows for the existence of sector-specific frictions, called wedges, drawing on Chari, Kehoe and McGrattan (2007) and Aoki (2012).

Aoki (2012) assumes constant returns to scale and perfect competition in all markets and free mobility of production inputs. Admittedly, these assumptions are strong; however, our goal is precisely to explore how far the observed allocation of factors lies from a benchmark of perfect competition. In particular, following Chari, Kehoe and McGrattan (2007), the wedges take the form of taxes or subsidies on the price of the production inputs and are synthetic indicators that incorporate and absorb *any* deviation from the frictionless perfectly competitive outcome, regardless of what actually caused such deviations (distortionary taxation, non-competitive market structures, etc.).

In our economy there is one final good sector and n intermediate

sectors. Aggregate value added in the economy V_t is a CES aggregator that combines the value added produced by each sector i, V_{it}

$$V_t = \left[\sum_i \gamma_i V_{it}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{1}$$

where $\epsilon \geq 0$ is the elasticity of substitution between any pair of intermediates and $\gamma_i \in (0,1)$ is the weight of sector i, $i = 1, ..., n$.

In every period t, the profit maximization of the final good sector is described by

$$\max_{\{V_{it}\}_{i=1}^n} \left\{ p_t \left[\sum_i \gamma_i V_{it}^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} - \sum_i p_{it} V_{it} \right\}$$

We denote the price of each intermediate good by p_{it} and the price of the final good by p_t. We normalize $p_t = 1$ for all t, then the n first-order conditions become

$$p_{it} = \gamma_i \left(\frac{V_{it}}{V_t} \right)^{-\frac{1}{\epsilon}}, \; i = 1, ..., n \tag{2}$$

All intermediate goods are produced competitively using labor (L) and capital (K) as inputs with different Hicks-neutral technologies and factor proportions.[2]specifically

$$V_{it} = A_{it} K_{it}^{\alpha_i} L_{it}^{1-\alpha_i} \tag{3}$$

The α_i are assumed to be sector-specific and time-invariant and total factor productivities A_{it} to vary both across sectors and over time. In every period t, the representative price-taker firm in sector i chooses labor and capital to solve

$$\max_{\{K_{it}, L_{it}\}} p_{it} V_{it} - (1 + \tau_{K_{it}}) p_{K_t} K_{it} - (1 + \tau_{L_{it}}) p_{L_t} L_{it}$$

[2]We concentrate on value added in order to have a direct comparison with GDP. We acknowledge the importance of considering also the role of intermediate inputs, as they may be important sources of distortions, particularly in countries such as India and China (Jones, 2013). However, while it is immediate to map within-sector input distortions to within-sector misallocations, it is less easy to do so when considering between-sectors distortions, since intermediate inputs are more than any other inputs sector-specific.

where p_{L_t} is the price of labor, p_{K_t} is the remuneration of capital and $(1+\tau_{K_{it}})$ and $(1+\tau_{L_{it}})$ are the wedges on factor prices. Then the first-order conditions are as follows

$$(1+\tau_{K_{it}})p_{K_t} = \frac{\alpha_i p_{it} V_{it}}{K_{it}} \tag{4}$$

and

$$(1+\tau_{L_{it}})p_{L_t} = \frac{(1-\alpha_i) p_{it} V_{it}}{L_{it}} \tag{5}$$

Definition 1. In every period t, given $\{\tau_{K_{it}}\}_{i=1}^n$, $\{\tau_{L_{it}}\}_{i=1}^n$, $\{A_{it}\}_{i=1}^n$, K_t and L_t, the static competitive equilibrium for this economy is defined as quantities $\{K_{it}, L_{it}\}_{i=1}^n$ and prices $\{p_{K_t}, p_{L_t}\}$ so that first-order conditions are satisfied in all sectors and factor markets clear, *i.e.*

$$K_t = \sum_i K_{it} \tag{6}$$

and

$$L_t = \sum_i L_{it} \tag{7}$$

The equilibrium is defined both with and without frictions.

Case 1: No frictions.

When $\tau_{K_{it}} = \tau_{L_{it}} = 0 \; \forall i$ the economy is in perfect competition, wedges do not distort prices and therefore the choice of factor inputs is efficient and output is maximized. Under these conditions the set up resembles the one proposed by Acemoglu and Guerrieri (2008; AG henceforth), but extended to n sectors (see also Herrendorf *et al.*, 2014). Taking as given K_t, L_t, and A_{it}, assuming $\tau_{K_{it}} = \tau_{L_{it}} = 0 \; \forall i, t$ and combining (2), (4), (5) along with the market clearing conditions, we can determine the share of K_t and L_t allocated to each sector

$$\kappa_{it}^* \equiv \left(\frac{K_{it}}{K_t}\right)^* = \frac{\alpha_i p_{it} V_{it}}{\sum_j \alpha_j p_{jt} V_{jt}} \tag{8}$$

$$\xi_{it}^* \equiv \left(\frac{L_{it}}{L_t}\right)^* = \frac{(1-\alpha_i) p_{it} V_{it}}{\sum_j (1-\alpha_j) p_{jt} V_{jt}} \tag{9}$$

Where the asterisk indicates that shares are at their optimal levels. Combining (8), (9) we get

$$\frac{1-\alpha_i}{\alpha_i}\frac{K_{it}}{L_{it}} = \frac{1-\alpha_j}{\alpha_j}\frac{K_{jt}}{L_{jt}} \tag{10}$$

Equation (10) has static and dynamic implications: on the static side, it implies that sectors with larger capital shares have larger capital-to-labor ratios; on the dynamic one, it implies that, if the capital shares are constant over time, $\frac{K_{it}}{L_{it}}$ grows at the same rate across sectors. We are now interested in determining how capital shares change with capital accumulation and technological developments. As in AG, we can apply the implicit function theorem to equation (8) to derive the following

$$\frac{\partial \kappa_{it}}{\partial K_t}\frac{K_t}{\kappa_{it}} = -\frac{\partial \xi_{it}}{\partial L_t}\frac{L_t}{\xi_{it}} = \frac{(1-\epsilon)\Delta_{it}}{\Psi_t} \tag{11}$$

$$\frac{\partial \kappa_{it}}{\partial A_{jt}}\frac{A_{jt}}{\kappa_{it}} = -\frac{\partial \kappa_{it}}{\partial A_{it}}\frac{A_{it}}{\kappa_{it}} = \frac{(1-\epsilon)(1-\kappa_{it})}{\Psi_t} \tag{12}$$

Where $\Delta_{it} = \sum_{j\neq i}(\alpha_j - \alpha_i)\kappa_{jt}$ and Ψ is a positive number.[3]Setting $n = 2$ we replicate AG's results. When $n > 2$ we can sign (11) only for the least and most capital intensive sectors. Both theoretical intuition and existing empirical estimates point to $\epsilon < 1$, so we will assume that this holds true hereafter.[4] Under this assumption, equation (11) establishes that the share of capital allocated to the least capital intensive sector increases with the stock of K_t as $(1-\epsilon)\Delta_{it} > 0$. The converse is true for the most capital intensive sector.[5] Nothing can be said for the sectors at an intermediate level of capital intensity. The result is triggered by relative price adjustments, in fact, when $\epsilon < 1$, equation (2) implies that the relative price of the least capital intensive sector will increase more than proportionally, inducing a greater share of capital to be allocated to this sector.[6]Hence, as long as cap-

[3]$\Psi_t \equiv 1 + (1-\epsilon)\left[(n-2)\kappa_{it} + \Delta_{it}\left(\sum_{j\neq i}\frac{\alpha_i}{\alpha_j}\left(\frac{1-\alpha_j}{1-\alpha_i}\right) - 1\right)\xi_{it}\right] > 0$ if $\epsilon < 1$.

[4]According to AG, $\epsilon < 1$ is the most reasonable hypothesis. For the U.S. they estimate an elasticity of 0.76. In our case we verified that relative prices in China and India moved consistently with this assumption.

[5]The results in (11) also apply to ξ_{it}, in fact $\frac{\partial \xi_{it}}{\partial K_t}\frac{K_t}{\xi_{it}} = -\frac{\partial \xi_{it}}{\partial L_t}\frac{L_t}{\xi_{it}} > 0$ if and only if $(1-\epsilon)\Delta_{it} > 0$.

[6]Recall that $\frac{p_{it}}{p_{jt}} = \frac{\gamma_i}{\gamma_j}\left(\frac{V_{jt}}{V_{it}}\right)^{\frac{1}{\epsilon}}$.

ital shares differs across sectors and $\frac{K_t}{L_t}$ is increasing over time, value added growth will be non-balanced and capital and labor will be allocated unevenly across sectors. Equation (12), in turn, states that the share of capital allocated to a sector decreases with an improvement in the technology of the sector itself, while the converse is true when technology improves in other sectors. The results are again driven by relative price adjustments, which induce a reallocation of factors away from the sector whose relative price declines.[7]

Comparing the prediction of the model with the stylized facts described in the previous section, we can draw some preliminary conclusions. First, over time the shares of capital and labor in China and India did not always move in the same direction. This finding is consistent with the predictions of (10). Second, as capital deepening in the two economies increased, the shares of capital and labor allocated across sectors changed. In China it was the tertiary sector (at an intermediate level of capital intensity) that attracted relatively more capital and labor. In India the share of capital allocated to industry (on average the most capital intensive sector) increased, while it halved in the primary sector (the least capital intensive) and stagnated in the tertiary one. These findings seem to contradict the predictions of equation (11). However, we need to consider that technological progress across industries has been uneven. For instance, in China technological progress was on average faster in the primary and secondary sectors (see Table 3). In the case of India, technological progress was much faster in the tertiary industry compared to the rest of the economy. Hence, the observed changes in the capital share across sectors would be in line with the predictions of equation (12).

To summarize, as capital deepening proceeded in China and India, output growth and factor allocation were uneven across sectors and between the two countries. Taking into account technological upgrading and within-sectors structural transformation, we can reconcile the observed development patterns with the theoretical model of unbalanced growth. Nonetheless, we cannot rule out market distortions that prevented capital and labor from moving freely across sectors, inducing a sub-optimal allocation of production factors, which ultimately resulted in losses of potential output. The next section explores this issue by introducing wedges into the model.

[7]Equation (11) and (12) are the basis of AG's unbalanced growth model.

Case 2: Wedges and allocation inefficiency

Whenever $\tau_{K_{it}} \neq 0$ or $\tau_{L_{it}} \neq 0$ for some (i,t) distortions prevent the optimal allocation from replicating the perfectly competitive equilibrium allocation.
The equilibrium conditions (4)-(9) allow us to compute the implied distortions:

$$\lambda_{K_{it}} \equiv \frac{K_{it}}{K_t} / \frac{K_{it}}{K_t}^* = \frac{\sum_j \left(1+\tau_{K_{jt}}\right)\left(K_{jt}/K_t\right)}{\left(1+\tau_{K_{it}}\right)} \tag{13}$$

$$\lambda_{Lit} \equiv \frac{L_{it}}{L_t} / \frac{L_{it}}{L_t}^* = \frac{\sum_j \left(1+\tau_{Ljt}\right)\left(L_{jt}/L_t\right)}{\left(1+\tau_{Lit}\right)} \tag{14}$$

where λ_{K_i} and λ_{L_i} are terms that include all frictions that we call *relative wedges*.cally,

If $\tau_{K_i} = \tau_{L_i} = 0$, $\forall i$ we are back to the frictionless scenario, the allocation of factor inputs is efficient and output is maximized. In this case $\lambda_{K_i} = \lambda_{L_i} = 1$, as well.

If $\tau_{K_i} = \tau_{L_i} = \tau \neq 0$, $\forall i$ then the frictions are uniform across sectors and factors. In this case frictions act as lump sum taxes, the output produced is lower but the allocation of factors is still Pareto efficient in the sense that total output could be increased only by increasing the overall quantity of labor or capital, not through a reallocation of production factors across sectors. In this case it is still true that $\lambda_{K_i} = \lambda_{L_i} = 1 \; \forall i$.

Finally, whenever $\tau_{J_i} \neq \tau_{J_j}, J = L, K$ for some (i,j), *i.e.* there are at least two frictions which differ from each other, then this uneven distribution of wedges induces not only a loss in output but also a sub-optimal resource allocation. Let's start with an economy in the condition described in the previous paragraph with the same wedge on both labor and capital in all sectors. Suppose that τ_{K_1} is lower relative to the other τ's, then $\lambda_{K_1} > 1$ and $\lambda_{K_{i>1}} < 1$. The fact that capital becomes relatively less expensive in sector 1 implies an over-allocation in this sector. At the same time, capital becomes relatively more expensive in all other sectors inducing an under-allocation. In other words, without frictions K_1 would be lower and $K_{i>1}$ would be higher. A departure from the mean in *one* sector induces a misallocation of the production factors in *all* sectors. Therefore, in terms of efficient allocation, what matters is not only how much their level diverges from 1 but also the asymmetry of their distribution across sectors.

4 Measuring wedges and misallocation costs

The theoretical framework presented in section 3 is now exploited to answer the following questions: (i) is there evidence that the allocation of labor and capital in China and India might have been inefficient during the period under consideration? If that is the case, (ii) how does the actual distribution of factors compare to the one arising in a frictionless scenario? and (iii) how do inefficiencies evolve over time? Finally, (iv) what are the costs, in terms of lower aggregate TPF, of such departures from the benchmark scenario of perfect competition?

To answer these questions we build a dataset for China and India that includes: nominal value added, quality-adjusted capital stock and the number of quality-adjusted employed persons, for 26 sectors over 31 years (from 1980 to 2010). Our dataset combines information from the *India KLEMS Project* (Reserve Bank of India, 2014) and the *China Industrial Productivity Database* (*Research Institute of Economy, Trade & Industry*, RIETI). For capital income shares we use capital compensation as a share of total value added. We consider the US as the technological benchmark, hence we take average capital income shares over the period 1980-2010 computed on US data (from Dale*et al.*, 2012); we perform also robustness checks using both time-varying and country-specific capital income shares. All the series are adjusted for their cyclical components.[8] Preliminary evidence in favor of factor misallocations is derived by inspecting sectoral capital-to-labor ratios versus sectoral capital shares. Such an inspection reveals that in 1980 the actual ratios in both countries did not satisfy the equilibrium condition (10), no matter whether US capital income shares or country-specific income shares are considered (Figure 1). Also dynamically, data show that the capital-to-labor ratio did not grow at the same rate across sectors, however, this may not be necessarily a bad thing if actual ratios were far from optimal at the beginning of the observation period; in such instances different growth rates may bring about more efficient allocations at later stages. If this is the case, we should observe distortions falling over time. So our next step is to estimate capital and labor distortions at each time t and evaluate their size and evolution over time.

To estimate λ_{K_i} and λ_{L_i} we use equations (8), (9), (13) and (14).

[8]For details on the construction of the dataset refer to the Appendix.

As noted above, the more the wedges differ across sectors, the higher the level of distortion in the allocation of production factors compared to the frictionless scenario.[9] Therefore, to find evidence of misallocation we computed the Gini coefficient of the distributions of λ_{K_i} and λ_{L_i} in all the sample years.[10] The coefficients are weighted by the sector shares in nominal value added, so that the more the wedge in a sector diverges from the average level and the higher is that sector's share in value added, the more it would contribute to the overall dispersion and allocation inefficiency. The coefficients are computed both across all sectors and excluding agriculture to quantify how much of the overall dispersion comes from that sector, which is traditionally very important in both countries.

Figures 2 and 3 provide strong evidence of allocation inefficiency. Wedges are quite dispersed around their mean for both labor and capital. Over time the dispersion of the wedges on labor displayed little or no improvement in India. In China, instead, it increased steadily until the early 2000s and then dropped, driven by the underlying dynamics of the wedge on agricultural labor which increased dramatically at first and declined afterwards, before converging towards the mean. Excluding agriculture, dispersions are much less pronounced in both countries, with clear signs of improvements in India. The dispersion of the wedges on capital remained steady in India over the whole sample period while in China it displayed an upward trend since 1995.

Given the evidence of misallocation of the production factors, we further exploit the theoretical framework to derive indications on how capital and labor should be allocated instead. In particular, we used (8) and (9) to derive the *optimal* K_i^* and L_i^*, *i.e.* the allocations in each sector that would arise in a scenario with no frictions. K_i^* and L_i^* are computed assuming that $\lambda_{J_i} = 1$, $\forall J = K, L$ and $\forall i = 1, ..., n$ and taking as given the aggregate stocks of K and L and the value added

[9]For this reason, 'dispersion of wedges', 'inefficiency', 'misallocation' or 'distortion' of production factors may be used as synonymous in the text.

[10]The level of dispersion could also be measured using the standard deviation as, for instance, in Hsieh and Klenow (2009). We preferred to use a (weighted) Gini coefficient for two reasons. First, the standard deviation assigns the same weight to each observation. With sector-level data, as in our case, a relatively small distortion arising in a sector that accounts for a large share of total value added would contribute more to the overall misallocation than a stronger distortion in a smaller sector. Second, the Gini coefficient was preferred to the standard deviation because the value of the latter depends on the scale of the underlined variable; instead, the Gini coefficient is a 0-1 index which makes it more comparable across countries and across production factors.

shares observed at each time t. The experiment is then repeated for all sample years. By comparing K_i and L_i to K_i^* and L_i^* we computed, for each sample year, the percentages of the total stocks of capital and labor that were misallocated. The results are reported in Figure 4. In most years the percentage of misallocated labor is above that on capital. The situation is reversed in China after 2000 as the share of misallocated workers declined while the share of misallocated capital increased.

The sub-optimality of the allocation implies a waste of aggregate output through a lower aggregate TFP.[11]Therefore, in order to measure the potential gains in terms of higher aggregate TFP we computed in each time period an index of Allocation Efficiency (AE_t). Assuming that sector-specific TFPs do not change across states, our index is simply derived as follows:

$$AE_{it} \equiv \ln\left(\frac{V_{it}}{V_{it}^*}\right) = \alpha_i \ln\left(\frac{K_{it}}{K_{it}^*}\right) + (1-\alpha_i)\ln\left(\frac{L_{it}}{L_{it}^*}\right) \tag{15}$$

Using (13) and (14) we get:

$$AE_{it} = \alpha_i \ln \lambda_{K_{it}} + (1-\alpha_i)\ln \lambda_{L_{it}} \tag{16}$$

As proposed by Aoki (2012), we can apply the mean value theorem to the aggregate value-added function. Hence we have

$$AE_t = \ln\left(\frac{V_t}{V_t*}\right) = \sum_i \frac{\partial \ln(V_t)}{\partial \ln(V_{it})} \ln\left(\frac{V_{it}}{V_{it}*}\right) \tag{17}$$

Recalling that $\frac{\partial \ln(V_t)}{\partial \ln(V_{it})} = \frac{p_{it}V_{it}}{V_t}$, our measure of aggregate efficiency simply becomes:[12]

$$|AE_t| = \left|\sum_i \sigma_{it}\left\{\alpha_i \ln \lambda_{K_{it}} + (1-\alpha_i)\ln \lambda_{L_{it}}\right\}\right| \tag{18}$$

Where $\sigma_{it} \equiv \frac{p_{it}V_{it}}{V_t}$. Note that AE is negative as the contribution of wedges is detrimental to the aggregate TFP, therefore we take the absolute value. In each year, AE_t measures the (percentage) loss in term

[11]Note that we are not computing the optimal accumulation path, because we do not model the investment choice. Nevertheless, from our framework we can derive, for the endowments of K, L and technology available at time t, how far the allocation of factors across sectors is from a perfectly competitive benchmark.

[12]A similar exercise is run for advanced economies in Dabla-Norris *et al.* (2015).

of aggregate TFP due to the deviation from the perfectly competitive benchmark (Figure 5). A lower (higher) level of $|AE_t|$ relative to the previous year indicates that the TFP gap is lower (higher) and is consistent with an improvement (worsening) in the allocation efficiency of the production factors.

Results point to the existence of large TFP gaps. In China they remained in the range of 25-30% of the observed TFP until 2000, then increased above 30% peaking at 35% in 2007. The reduction in agricultural employment and the improvements in the allocation of labor after 2000, helped in containing overall TFP losses in China; excluding agriculture, losses have been trending upwards since 1995, driven by growing capital misallocation, and increased by 10 percentage points, to 30% in 2010. Our results are consistent with Brandt *et al.* (2013), who find that the misallocation of capital between the state and the non-state sectors increased significantly after 1997. On the contrary, in India, excess labor in agriculture is still a major drag on overall efficiency: TFP gaps decreased from slightly above 40% in 1980 to 35% around 1995, but then remained in the range of 35-40%. Excluding agriculture, TFP gaps in India are reduced by 15 percentage points, in the range of 20-25% over the entire sample period. These findings reflect quite well the extremely slow process of reallocating labor from the agricultural sector to industry and services compared to other emerging and developing countries (Bosworth *et al.*, 2007; Di Stefano and Marconi, 2015), the main reason for that is often found to be rooted in severe skill-mismatches on the labor market (Kotwal *et al.*, 2011).

Even though the upward trend in the misallocation of capital is much more pronounced in China, it is visible in India too. Increasing trends in capital misallocations have been documented also for some advanced countries, such Spain and Portugal (Gopinath *et al.*, 2015; Dias *et al.*, 2015), as well as for Eastern and Central European countries (Gamberoni *et al.*, 2016), suggesting that in many instances fast credit expansion has been accompanied by growing inefficiencies in the allocation of capital. In China the misallocation of capital accounted, on average, for about 40% of the total loss in TFP but its contribution has been increasing since 1999 and overcame that of labor since 2005; over the same period, the inefficiency arising from labor has been lowering; the role of capital is even more apparent when agriculture is excluded (Figure 5, lower-left panel). In India the contribution of capital to the total loss in TFP increased, although with a less pro-

nounced trend; in the non-agricultural sector, capital misallocation is the largest contributor to the total loss in TFP (Figure 5, lower-right panel).

In order to assess the robustness of our results we perform two exercises. The first is to compute TFP losses stemming from capital and labor misallocations in the United States and compare the results with China and India. Results, reported in Figure 6, show that aggregate distortions in the US are very low throughout the period and tended to decline from around 7% in 1980 to about 5% in 2010. This result appears particularly appealing, as it confirms that, as opposed to China and India, factors' distortions in the US are very low and potential gains in terms of aggregate TFP stemming from factor allocation are very limited. The second robustness check is to verify whether such a result is driven by the choice of α_i. We computed misallocations under several alternative set of α_i's, using both country-specific α_i's and time-varying α_i's. Results, shown in Figures A1-A6 indicate that the α_i's mainly affect the level of capital and labor distortions but not their dynamics. In the case of India, we have almost parallel shifts in the rage of 5 percentage points. In the case of China, the shifts observed until 1995 are mainly due to the α assigned to agriculture, which is much lower in the Chinese data (0.12, versus 0.42 in US data). Excluding agriculture, both the level and the dynamics of the distortions are very similar across the different set of α_i's for both labor and capital. Also, it is still true that aggregate inefficiency is increasing over time in China, driven by capital misallocation, while inefficiency is on average higher and stable over time in India. More details are reported in the Appendix.

5 Discussion of the results

In China the decreasing dispersion of the wedges on labor outside the primary sector is consistent with the reform process initiated in the early 1980s to transform the economy from a planning to a market economy. The marked improvements in the allocation of labor in the non-agricultural sector recorded throughout the 1990s (Figure 2) can be traced back to two main reforms: the opening-up policies, with the creation of the special economic zones, and the reforms of the state-owned enterprises (SOEs). While the first reform created productive jobs in the private sector, the second brought about the massive priva-

tization of several hundreds of SOEs and the layoff of millions of urban workers who fled towards the more productive private sector (Borin and Di Stefano, 2016). It is reasonable to think that the combination of these two reforms reduced the frictions on labor, by improving the mobility of workers in secondary and tertiary sectors.

The contemporaneous increase of the wedge on labor in agriculture is consistent with the growing gap in labor productivity between urban and rural areas, exacerbated by the restrictions imposed to rural/urban migrations. These restrictions were partially relaxed at the beginning of the 2000s, following China's entry into the World Trade Organization (WTO). The expansion of the export-oriented manufactures in the coastal provinces was, in fact, facilitated by the possibility given to rural workers to acquire temporary working permits; as a consequence, internal migration flows doubled compared to the previous decade (Chan, 2013).

The Gini distribution of wedges on capital shows that, as labor wedges became less dispersed, capital wedges became more dispersed over time (Figure 3), reflecting increasing distortions in the allocation of capital towards large and fast growing industries, such as 'Basic metal and fabricated metal products', 'Transport equipment' and 'Transport and storage', which had easier access to banking finance at subsidized prices (Table 5). The low cost of capital has long been a key feature of the investment-driven growth model followed by China through the financial repression. Repression was induced by government caps on interest rates, cross-border capital controls and tight government controls on bank lending. Indeed, the financial sector is the main area of missing or slow reforms in this period (Yao, 2014).

At first sight, it may sound surprising that the inefficiency in the allocation of capital increased while the country was experiencing its fastest growth period, as if the opening-up policies did not contribute to the reduction of distortions, particularly in those sectors more exposed to international competition. However, it is often found in the literature (see, for example, Caballero and Hammour 1994; Mortensen and Pissarides 1994) that misallocation increases in periods of high growth and decreases in recessionary periods when some forced 'cleansing' mechanism operates. Moreover, as long as investment decisions are only partially reversible, it may well be the case that productivity shocks in one sector are not promptly accompanied by capital stock adjustments (Asker *et al.*, 2014). Also, since in our framework what matters is the relative distribution of wedges, the reduction in one sec-

tor may cause, *ceteris paribus*, an increase in the overall dispersion of the wedges, being detrimental to allocation efficiency. In fact, the persistence of distortions in other sectors prevent a swift reallocation of resources towards (or away from) the sector where the wedge actually declined.

In 2010 about 35% of capital and 27% of labor were still misallocated in China. If the abundant stocks of labor and capital had been allocated efficiently, aggregate TFP would have been 35% above the level observed in the mid-2000s and still above 30% in 2010.

In India, several waves of structural reforms were implemented between 1980 and 2010. In the 1980s a first wave of reforms towards the liberalization reduced the barriers to international trade and relaxed industrial controls. A second wave was launched in 1991, opening the country to international trade and foreign direct investment and further dismantling most central government controls on the industrial sector, maintaining strict public control on three industries only: defense, nuclear power and rail transportation.

There is an extensive literature assessing the impact of the waves of reform on the performance of the Indian economy (Agarwal *et al.*, 2013; Ahluwalia, 2002; Herd, 2011). Most authors argue that the reforms of the 1980s brought higher but unsustainable growth, partially boosted by growing public debt and external borrowing. Unlike the first, the second wave is instead considered to have been broader and deeper, greatly improving the business environment and bringing a more sustainable growth model. Our results are partially consistent with this view. On the one hand, we did find evidence that factors started to be allocated more efficiently in 1985, after the implementation of the first wave of reforms. On the other hand, we did not detect a clear structural break after 1991 and cannot conclude that the second wave of reforms was more effective, at least in terms of factor allocation efficiency. In fact, the TFP gap declined from around 40% in 1985 to around 35% in 1995 but the decline was rather smooth. Moreover, the improvements also started to slow and were eventually reversed in 1995, signaling that the benefits of the reforms of the 1990s were exhausted quite rapidly. This fact is consistent with the high and persistent misallocation of labor in India. Not only the strict regulation of the labor market limited the mobility of workers inhibiting the efficient reallocation of the labor force across sectors, but also human capital mismatches may explain the severe shortages of labor in the most productive sectors, such as machinery and equipment and

financial services.

Tables 5 and 6 display the wedges on labor and capital across sectors. Values above (below) one indicate an excessive (deficient) allocation of the factor in the sector. For instance, in agriculture we notice a persistent surplus of labor and a deficit of capital in both countries, indicating that labor is "subsidized" and capital "taxed" in the agriculture. The agriculture sector is still very protected in many advanced countries too (Dabla-Norris *et al.*, 2015), however, while in advanced countries distortions favor both labor and capital, in China and India, distortions in agriculture favor employment but discourage capital formation. In China implicit employment subsidies are quite evident also in the personal services sector (Education, Health and other services), likely due to lack of competition (for advanced countries similar results are found by Dabla-Norris *et al.*, 2015). On the contrary, in India, labor shortages remain severe across all service sectors. Capital misallocations are particularly acute in the 'Transport and storage' sector, where it appears heavily subsidized, and in the 'Financial services' sector, where instead, due to high returns, it results implicitly taxed. This pattern is also found by Aoki (2012) for some advanced countries. In China, capital distortions are very strong in the personal services sector, as well as in 'Construction' and in the 'Transport equipment' sector. In India, excessive capital is more pronounced and diffused across the manufacturing sector.

Figure 7 summarizes our findings. We report labor and capital gaps, that is the difference between the optimal and the actual shares of factors in the primary, secondary and tertiary industries. A positive gap indicates that the share of factor employed in the sector is below the optimal level, on the contrary, a negative gap indicates that the sector employs an excessive amount of factor compared to the optimal level. Results show that while there is too much labor in agriculture in both countries, the surplus in India is double that in China (for a discussion on the productivity in the agriculture sector in China and India, see also Bosworth and Collins, 2008). Also in the secondary and tertiary sectors surpluses or deficits of labor and capital are different across the two countries, reflecting different sector productivities. In China, the productivity of labor and capital is much higher in the secondary sector than in the tertiary one. In India, the situation is almost reversed as the tertiary sector is much more productive than the secondary one. This finding is again consistent with the different development paths followed by the two countries over the thirty-years

period under consideration. In China, growth was driven by the secondary sector, particularly by the export-oriented manufacturing sector. In India, the tertiary sector, particularly the ICT sector, was the major driver of growth and technological upgrading (Bosworth and Collins, 2008). The backwardness of the service sector in China and the extremely weakness of the manufacturing sector in India have been extensively documented in the literature (OECD 2015; Bosworth and Collins, 2008). To conclude, our analysis confirms that reform priorities differ across the two countries. In China reforms should address the low productivity of the tertiary sector and capital market distortions. In India, reforms should aim at improving the productivity of the secondary sector and should focus more on the functioning of the labor market as well as on human capital formation.

6 Conclusions

In this paper we find strong evidence of large distortions in the allocation of labor and capital across sectors China and India, but with some country-specific patterns. If capital and labor were reallocated optimally, we estimate that the aggregate TFP could be raised by 25 to 35% in China and by 35 to 40% in India. Our analysis provides some indication of the reform priorities that China and India are facing. In the case of China reforms should address the low productivity of the tertiary sector and should aim at removing capital market distortions. In India, reforms should aim at improving the productivity of the secondary sector and should focus on the labor market functioning and human capital formation.

There are some limitations to this paper's analysis. First of all, we do not model the investment choice and the labor supply, hence we cannot derive indications on the optimal growth path that would arise if frictions were to be removed. For example, we are not able to discuss to what extent the existing allocative distortions may have caused the aggregate pace of capital accumulation to exceed or fall short of optimal capital levels, an issue of considerable importance both in China and India. Still, our comparative statics analysis can be used to quantify the amount of wasted output arising from the misallocation of the given stocks of resources. Another limitation is that our wedges absorb any deviation from the competitive benchmark and therefore this framework cannot be used to disentangle the

relative role of alternative sources of distortions, such as frictions arising from adjustment costs to capital rather than policy-induced distortions. Moreover, we assume constant technology, but, in fact, if it changed bringing about allocation adjustments, those adjustments could mistakenly contribute to the estimated wedges and inefficiency (Foster *et al.*, 2016).

Important kinds of distortions that would be interesting to disentangle are those arising from policies aimed at reducing geographical disparities within a country, generally perceived as welfare improving. These kinds of distortive policies are likely to be very relevant in both China and India, given their size and vast internal disparities. This is certainly an interesting extension that we leave for future research.

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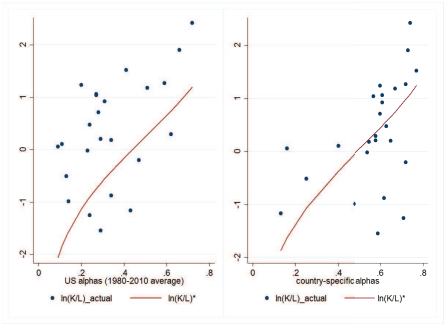
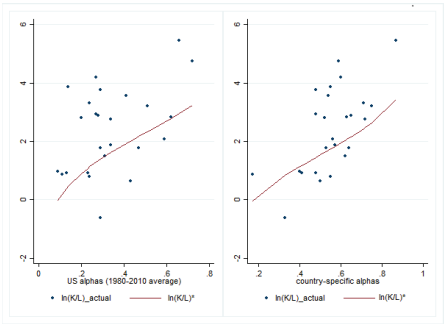
Figures

Figure 1: Actual and optimal sectoral capital-to-labor ratios ordered by sectoral capital income shares in 1980



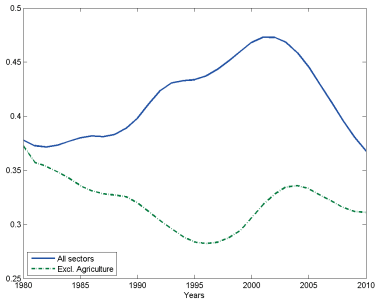
(a) China



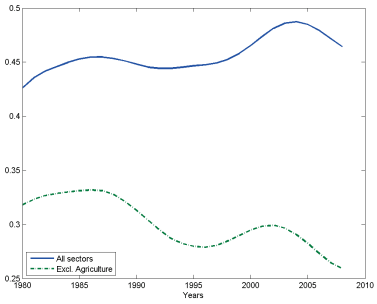
(b) India

Note: On the y-axis: natural log of units of capital expressed in national currency per worker. On the x-axis: capital income shares

Figure 2: Gini coefficients of the labor wedge distributions

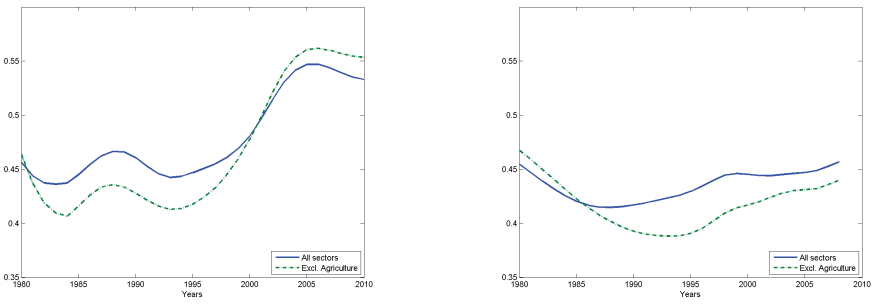


(a) China



(b) India

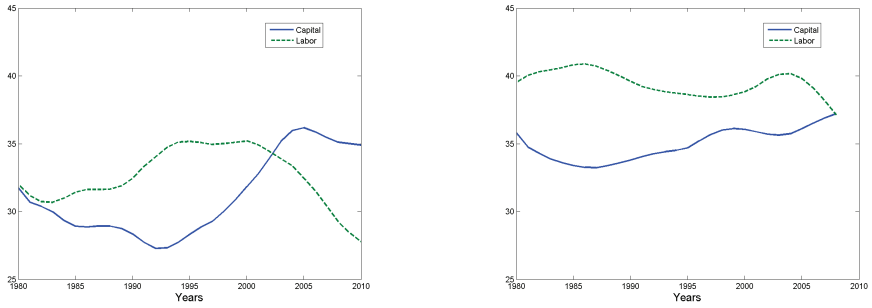
Figure 3: Gini coefficients of the capital wedge distributions



(a) China (b) India

Note: Gini coefficients are weighted by sector shares in total value added.

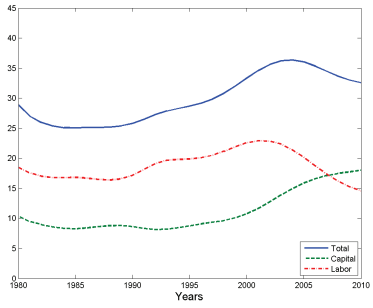
Figure 4: Misallocated capital and labor (% of total stock)



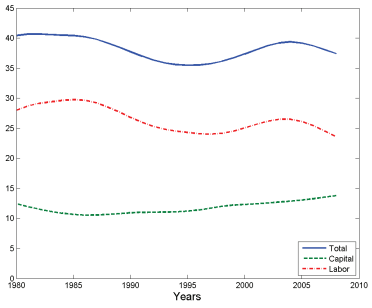
(a) China (b) India

Source: Authors' calculations.

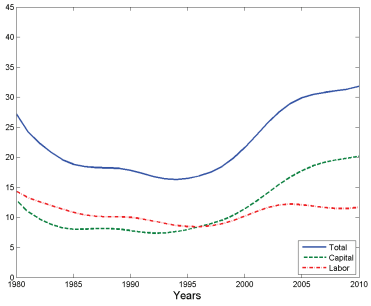
Figure 5: Loss in aggregate TFP (% of potential TFP)



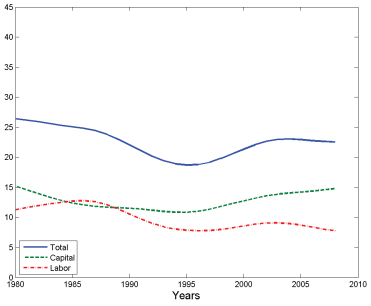
(a) China



(b) India

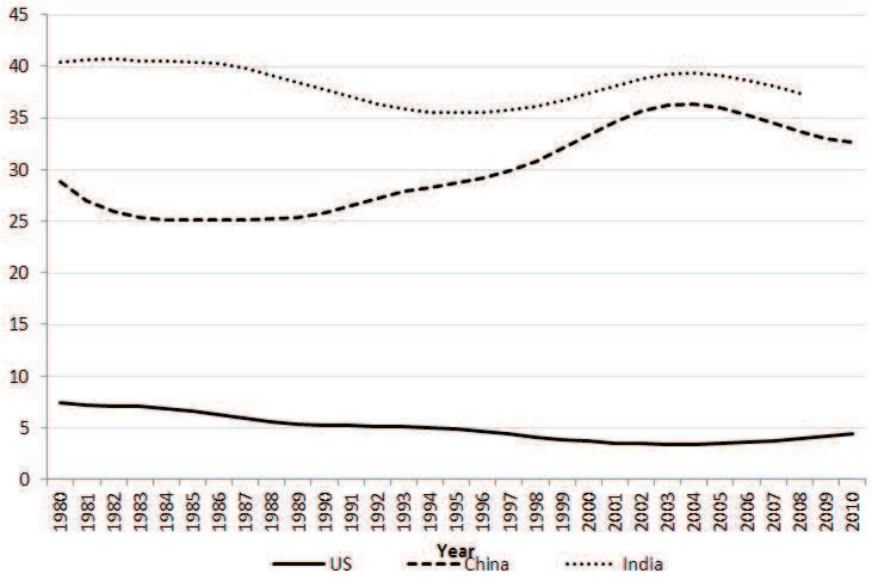


(c) China: excluding agriculture



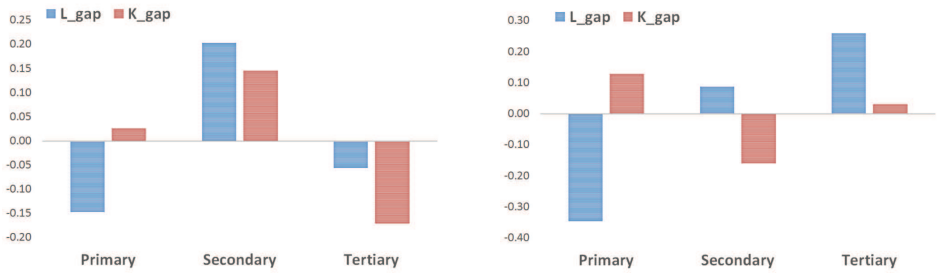
(d) India: excluding agriculture

Figure 6: Loss in aggregate TFP in China and India and the U.S.



Source: Authors' calculations based .

Figure 7: Labor and Capital gaps



(a) China (b) India

Note: $L_{gap} = \frac{L^*_{it}}{L_t} - \frac{L_{it}}{L_t}$ and $K_{gap} = \frac{K^*_{it}}{K_t} - \frac{K_{it}}{K_t}$.

Tables

Table 1: **Value added and urban consumption expenditure shares**

	Value added		**Urban consumption**	
	1980	2010	1980	2010
China:				
Primary	33	10	57	36
Secondary	46	47	n.a	31
Tertiary	22	43	n.a	34
India:				
Primary	38	16	60	41
Secondary	24	28	25	26
Tertiary	38	55	15	33

Source: India KLEMS, RIETI and CEIC.

Table 2: **Employment and capital allocated to each sector**(1)

	Employment		**Capital**		**Capital deepening**	
	% of total		% of total		PPP$ per worker	
	1980	2010	1980	2010	1980	2010
China(2):						
Primary	60	23	20	9	196	2,603
Secondary	23	27	45	35	1,139	8,428
Tertiary	17	50	35	56	1,228	7,477
India(3):						
Primary	70	53	23	11	1,755	3,164
Secondary	13	20	24	42	9,328	30,197
Tertiary	17	27	53	47	16,415	23,091

Source: India KLEMS and RIETI.

(1): Labor and capital adjusted for quality. PA sector excluded.

(2): First observations refer to 1981. Capital at 1990 prices.

The capital stock does not include land. Real estate sector excluded.

(3): Last observations refer to the fiscal year 2008-09. Capital at 1995 prices.

The capital stock includes land.

Table 3: **China: Growth decomposition**

	1981-1990	1991-2000	2001-2010
Primary:			
Value added	6.1	4.0	4.3
Employment	3.0	-0.9	-2.9
Labor productivity	3.0	4.9	7.4
Capital deepening	2.1	2.9	5.6
Human capital	-1.3	1.7	-0.9
TFP	2.2	0.3	2.8
Secondary:			
Value added	8.9	15.3	11.8
Employment	6.3	1.6	3.4
Labor productivity	2.5	13.4	8.2
Capital deepening	4.3	4.1	4.8
Human capital	-1.0	-0.2	1.0
TFP	-0.7	9.5	2.4
Tertiary:			
Value added	13.4	10.7	11.9
Employment	9.2	6.7	3.2
Labor productivity	3.8	3.8	8.5
Capital deepening	2.7	3.5	5.2
Human capital	-2.3	-0.4	3.4
TFP	3.4	0.6	-0.2

Sources: GGDC Database (Timmer *et al.*, 2013) and RIETI.

Table 4: **India: Growth decomposition**

	1981-1990	1991-2000	2001-2008
Primary:			
Value added	3.4	3.3	2.5
Employment	1.2	0.7	-0.4
Labor productivity	2.1	2.6	2.9
Capital deepening	0.3	0.9	2.5
Human capital	0.1	0.1	0.3
TFP	1.8	1.5	0.1
Secondary:			
Value added	6.7	6.4	8.2
Employment	2.5	0.9	1.5
Labor productivity	4.1	5.4	6.6
Capital deepening	3.5	3.0	4.2
Human capital	0.5	0.1	0.5
TFP	0.1	2.2	2.0
Tertiary:			
Value added	6.6	7.6	10.0
Employment	3.7	3.6	2.9
Labor productivity	2.8	3.8	6.9
Capital deepening	-0.5	0.7	2.2
Human capital	1.2	1.4	1.4
TFP	2.2	1.8	3.3

Sources: Based on India KLEMS data.

Table 5: **China: labor and capital wedges by sector**

	λ_{Li}		λ_{Ki}	
	1980-1997	1998-2010	1980-1997	1998-2010
Agriculture, hunting, forestry, fishing	2.2	3.0	0.5	0.7
Mining, quarrying	1.2	0.6	0.7	0.3
Food products, beverages, tobacco	0.6	0.5	0.7	0.6
Textiles products, leather, footwear	0.5	0.7	1.8	1.3
Products of wood	1.4	1.3	1.1	0.8
Paper products, printing, publishing	0.8	0.7	1.6	1.2
Coke, petroleum products; nuclear fuel	0.2	0.2	0.4	0.3
Chemicals, chemical products	0.3	0.4	0.6	0.5
Rubber, plastic products	0.8	0.9	0.8	0.8
Other non-metallic products	0.7	0.6	1.4	1.1
Basic metals, metal products	0.4	0.3	1.4	1.0
Other machinery	0.4	0.3	1.7	0.9
Electrical, optical equipment	0.4	0.4	1.4	1.1
Transport equipment	0.3	0.2	2.5	1.4
Other manufacturing; recycling	1.9	0.8	1.0	0.5
Electricity, gas, water supply	0.3	0.4	0.8	0.7
Construction	0.5	0.7	2.0	1.8
Trade	0.7	1.0	1.7	1.1
Hotels and restaurants	0.5	1.0	1.1	1.3
Transport and storage	0.5	0.5	3.3	5.7
Post, telecommunications	0.7	0.3	0.9	0.3
Financial services	0.2	0.5	0.5	0.3
Education	1.1	1.2	10.3	8.8
Health, social work	1.1	1.1	3.9	3.0
Other services	2.4	2.5	4.0	2.2

Note: Average distortions over the indicated period.

Values larger (smaller) than one indicate that there is an excess (deficit) of factor in the sector.

Table 6: **India: labor and capital wedges by sector**

	λ_{Li}		λ_{Ki}	
	1980-1997	1998-2010	1980-1997	1998-2010
Agriculture, hunting, forestry, fishing	2.4	3.0	0.5	0.5
Mining, quarrying	0.4	0.4	0.7	0.5
Food products, beverages, tobacco	1.4	1.5	1.5	1.4
Textiles products, leather, footwear	0.9	1.3	1.3	2.5
Products of wood	2.0	4.1	0.6	2.3
Paper products, printing, publishing	0.4	0.8	4.9	5.6
Coke, petroleum products; nuclear fuel	0.1	0.1	1.0	1.3
Chemicals, chemical products	0.3	0.3	0.9	1.0
Rubber, plastic products	0.3	0.4	1.0	1.7
Other non-metallic products	1.1	1.2	2.5	3.2
Basic metals, metal products	0.3	0.3	2.1	2.8
Other machinery	0.2	0.4	1.9	2.2
Electrical, optical equipment	0.1	0.2	1.5	1.9
Transport equipment	0.2	0.2	1.7	3.5
Other manufacturing; recycling	0.8	1.1	0.8	1.3
Electricity, gas, water supply	0.4	0.4	1.8	1.7
Construction	0.4	0.6	0.6	0.6
Trade	0.6	0.7	0.4	0.3
Hotels and restaurants	0.9	0.8	1.5	0.9
Transport and storage	0.4	0.5	1.7	1.3
Post, telecommunications	0.2	0.2	1.3	1.2
Financial services	0.2	0.2	0.1	0.2
Education	0.4	0.5	1.3	1.9
Health, social work	0.4	0.4	0.8	1.3
Other services	0.3	0.4	4.8	4.1

Note: Average distortions over the indicated period.

Values larger (smaller) than one indicate that there is an excess (deficit) of factor in the sector.

A Data

Our dataset combines information from three datasets distributed within the **World KLEMS initiative** (URL:http://www.worldklems.net). In particular:

- The *India KLEMS*, a project of the Indian Council for Research on International Economic Relations on productivity measurement that follows the EU-KLEMS (Capital, Labor, Energy, Material and Services) methodology. The project was funded by the Reserve Bank of India.
- The **China Industrial Productivity (CIP) Database** a collaborative effort between the Research Institute of Technology, Trade and Industry (RIETI) and the Institute of Economic Research at Hitotsubashi University.
- The **World KLEMS data on U.S.**, an adaptation from the database described in Jorgenson *et al.* (2010).

Our sector classification is described in Table A1. The data on nominal value added, capital and labor stocks are taken from countries' databases. The series are all adjusted for their cyclical components using a HP filter with smoothing parameter equal to 6.25. Instead, capital income shares are estimated from World KLEMS data on the U.S. Since capital compensation as a share of value added often displays cyclical components and is sensitive to tax considerations, we took sector-specific averages over the period 1980-2010. The choice to use the U.S. capital shares is motivated by the fact that these measures are usually very problematic, more so in developing countries.

Indian data - Selected variables:

- **'VA_current price':** Gross Value Added at current prices by industry, 1980 to 2008 (in Rs Crore).
- **'LAB_EMP':** Labour Person (,000) employed by industry, 1980 to 2008.
- **'LAB_Input':** Labour Input Index by industry, 1980 to 2008. This variable is used to adjust 'LAB_EMP' for quality.
- **'CAP_stock':** Capital Stock Input by industry, 1980 to 2008 (in Rs Crore). The variable is adjusted for quality.

Chinese data - The CIP data include 37 sectors. We have merged them to mimic the classification described in Table A1. Selected variables:

- **'VA_current price':** Value added by industry in ml current yuan; 1981-2010
- **'LAB_EMP':** Numbers employed by industry of all enterprises in 1000s; 1980-2010.
- **'LAB_Input':** Labor input index by industry (homogeneous hours worked), 1990=1; 1980-2010.
- **'CAP_stock':** Capital stock in "non-residential structures" by industry of all enterprises in ml 1990 yuan; 1980-2010
- **'CAP_Input':** Capital input index by industry (1990 = 1); 1980-2010. This variable is used to adjust 'CAP_stock' for quality.

U.S. data - The World KLEMS data on the U.S. include 40 sectors. We have merged them to mimic the classification described in Table A1. Selected variables:

- **'VA':** Gross value added at current basic prices (in millions of USD).
- **'CAP':** Capital compensation (in millions of USD).

Quality adjustments - In the KLEMS dataset the series of labor and capital can be adjusted for quality. In particular, the aggregate labor input L_i of sector i is defined as a Törnqvist volume index (Jorgenson, Gollop and Fraumeni, 1987) of workers by labor types as follows

$$\Delta lnL_i = \sum_l v_{l,i}^L \Delta lnL_{l,i} \tag{A.1}$$

with weights given by the shares of each labor type in the value of total labor compensation

$$v_{l,i}^L = \frac{w_{l,i}^L L_{l,i}}{\sum_i \sum_l w_{l,i}^L L_{l,i}} \tag{A.2}$$

where $\Delta lnL_{l,i}$ indicates the growth of persons employed by labor type l for sector i and weights are given by the period average shares of each type in the value of labor compensation, such that the sum of shares over all labor types is unity. The quality-adjusted labor stock that we used in our estimates has been computed imputing the rate of growth of the labor input index to the initial labor stock (number of employed persons). As in the case of labor, capital is also adjusted

to take into account different vintages and asset types. The aggregate capital service is measured by

$$\Delta lnK_i = \sum_k v_{k,i}^K \Delta lnK_{k,i} \tag{A.3}$$

with weights given by the shares of each asset in the value of total capital compensation

$$v_{k,i}^K = \frac{r_{k,i}^K K_{k,i}}{\sum_i \sum_k r_{k,i}^K K_{k,i}} \tag{A.4}$$

where $\Delta lnK_{k,i}$ indicates the volume growth of capital asset k. The capital stock used in our estimates incorporates the quality-adjustment.

Data cleaning - For both India and China we dropped sector 23 ('Public administration and defence; compulsory social security') because data on the capital stock of this sector are typically unreliable. For India we dropped sector 5 ('Wood and products of wood') because of missing data problems. For China we dropped the real estate sector (sector 32 in RIETI, code REA) has been dropped from the original dataset because of data unreliability issues. It was a component of sector 22 in our dataset ('Financial services') representing 6% of the value added in 2010.

The sectors remaining after the adjustments represent over 90% of the total value added.

Table A1: **Sector classification**

Sector n.	Description
1	Agriculture, hunting, forestry and fishing
2	Mining and quarrying
3	Food products, beverages and tobacco
4	Textiles, textile products, leather and footwear
5	Wood and products of wood
6	Pulp, paper, paper products, printing and publishing
7	Coke, refined petroleum products and nuclear fuel
8	Chemicals and chemical products
9	Rubber and plastic products
10	Other non-metallic mineral products
11	Basic metals and fabricated metal products
12	Other machinery
13	Electrical and optical equipment
14	Transport equipment
15	Other manufacturing; recycling
16	Electricity, gas and water supply
17	Construction
18	Trade
19	Hotels and restaurants
20	Transport and storage
21	Post and telecommunications
22	Financial services
23	Public administration and defence; compulsory social security
24	Education
25	Health and social work
26	Other services

B Sensitivity analysis: the α's

Te results in our model crucially depend on the α's. Specifically,

$$\lambda_{K_i}=\frac{\bar{\alpha}}{\sigma_i\alpha_i}\frac{K_i}{K}, \text{ and } \lambda_{L_i}=\frac{1-\bar{\alpha}}{\sigma_i(1-\alpha_i)}\frac{L_i}{L}$$

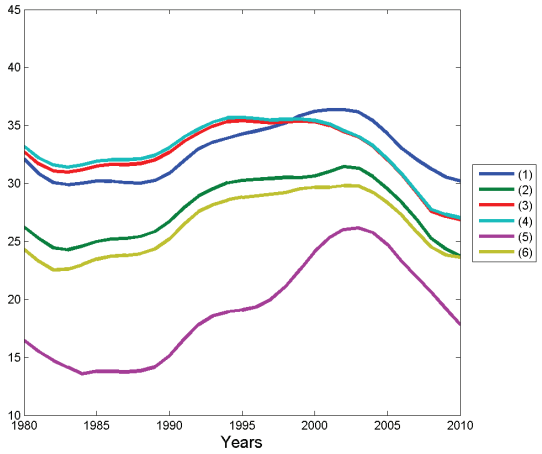
where σ_i is the sector share in nominal VA, $\bar{\alpha}=\sum_i \sigma_i\alpha_i$.

In theory the α_i's are sector-specific and time-invariant technological parameters. Under the assumption of a Cobb-Douglas sectoral production functions, they can be estimated by the sectoral distribution of capital income shares. This empirical counterpart is typically affected by estimation issues that arise because there is some arbitrariness in the way that income is partitioned between capital and labor in the national accounts (Miller, 2008); for instance, labor compensation for the same job could be registered as labor income if the worker is an employee or as proprietor's income if the worker is self-employed.

In our estimation the α_i's are measured by the capital compensation share in nominal value added in the United States, resulting from the World KLEMS dataset. In the dataset labor income and capital income shares add up to one. This choice relies on a number of arguments. First,although measurement errors in US data cannot be ruled out, it is likely that mismeasurement are even more severe for China and India. Second, the use of a common set of α_i's from the U.S. data, makes it easier to compare both across countries and with the existing literature on factor misallocation in these countries.

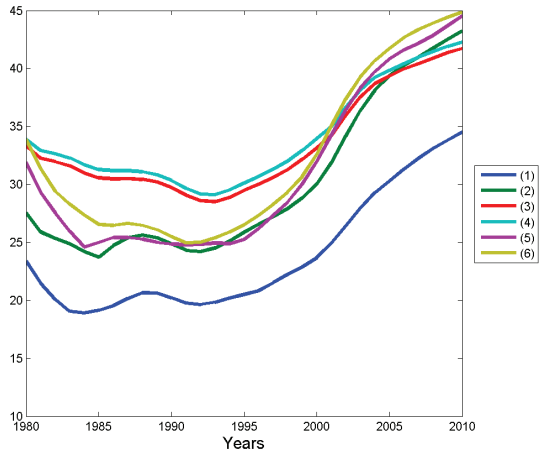
To assess the extent to which different choices of the α_i's would have changed our results, we computed the level of inefficiency in China and India under several alternatives, as detailed in the footnote of each figure. Figures A4 to A2 confirm that different α_i's change the results by shifting the level of inefficiency *but* they affect the time patterns only marginally, *i.e.* whenever we observe in our model that the level of misallocation decreases or increases, this would hold true even under alternative estimation choices for the capital income shares.

Figure A1: China: Inefficient allocation of labor under alternative choices of α's



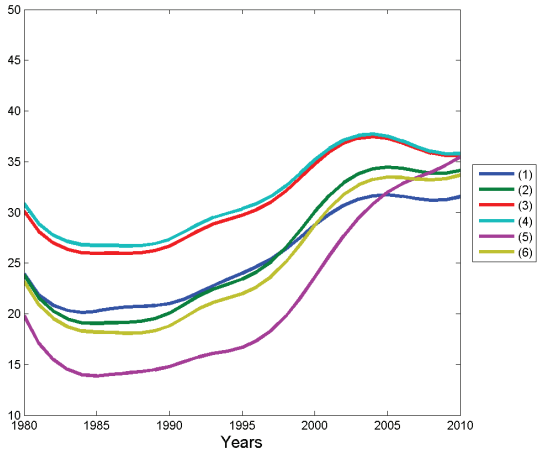
Note: Share of the stock of labor misallocated relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years; (2) Average of capital shares by sector for the U.S. in 1995-2010; (3) Average of capital shares by sector for the U.S. in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the U.S.; (5) Average of trend capital shares by sector from Chinese data; (6) Same as (3) with α_1 from Chinese data.

Figure A2: China: Inefficient allocation of capital under alternative choices of α's



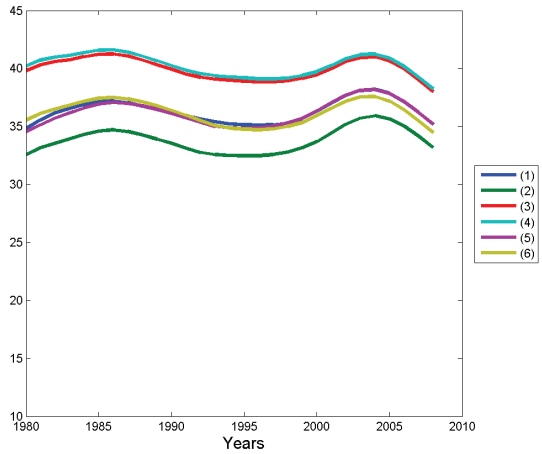
Note: Share of the stock of labor misallocated relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years; (2) Average of capital shares by sector for the U.S. in 1995-2010; (3) Average of capital shares by sector for the U.S. in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the U.S.; (5) Average of trend capital shares by sector from Chinese data; (6) Same as (3) with α_1 from Chinese data.

Figure A3: China: TFP gains under alternative choices of α's



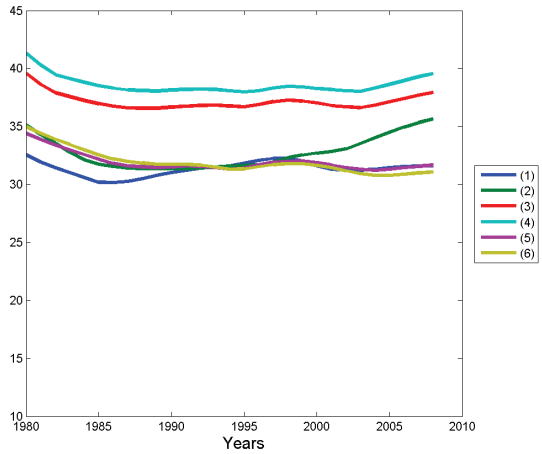
Note: Share of the stock of labor misallocated relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years; (2) Average of capital shares by sector for the U.S. in 1995-2010; (3) Average of capital shares by sector for the U.S. in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the U.S.; (5) Average of trend capital shares by sector from Chinese data; (6) Same as (3) with α_1 from Chinese data.

Figure A4: India: Inefficient allocation of labor under alternative choices of α's



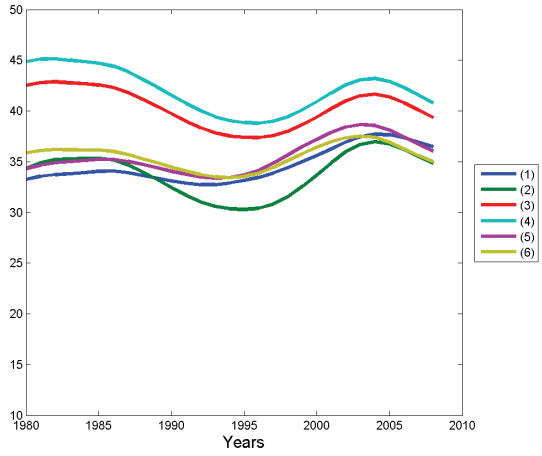
Note: Share of the stock of misallocated labor relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years ($\alpha = 0.5$); (2) Average of capital shares by sector for the US in 1995-2010; (3) Average of capital shares by sector for the US in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the US; (5) Average of trend capital shares by sector from Indian data; (6) Trend values from Indian data.

Figure A5: India: Inefficient allocation of capital under alternative choices of α's



Note: Share of the stock of labor misallocated relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years ($\alpha = 0.5$); (2) Average of capital shares by sector for the U.S. in 1995-2010; (3) Average of capital shares by sector for the U.S. in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the U.S.; (5) Average of trend capital shares by sector from Indian data; (6) Trend values from Indian data.

Figure A6: India: TFP potential gains under alternative choices of α's



Note: Share of the stock of labor misallocated relative to the frictionless scenario under the following alternative choices of α's: (1) Constant value in all sectors for all years ($\alpha = 0.5$); (2) Average of capital shares by sector for the U.S. in 1995-2010; (3) Average of capital shares by sector for the U.S. in 1980-2010 (option used in the paper); (4) Average of trend capital shares by sector for the U.S.; (5) Average of trend capital shares by sector from Indian data; (6) Trend values from Indian data.

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