Urbanization, Structural Transformation and Rural-Urban Disparities*

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Abstract

Over the past three decades India and China have experienced rapid economic growth along with a structural transformation of their economies from agriculture towards manufacturing and services. Underneath the overall similarity however is one significant difference: rural-urban wage gaps have been declining in India while they have widened in China. Crucially, in both countries, the majority of these wage gap dynamics are left *unexplained* by worker attributes. We formalize a two-sector-two-location model in which both structural transformation and urbanization respond endogenously to sectoral and aggregate productivity shocks. While the structural transformation effect tends to widen the urban-rural wage gap, the urbanization effect tends to reduce it. We show that the model can quantitatively account for both the wage convergence in India as well as the wage divergence in China.

JEL Classification: J6, R2

Keywords: Rural urban disparity, urbanization, structural transformation

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1 Introduction

The process of structural transformation wherein countries transform from being rural and agrarian to becoming more urbanized and non-agricultural is a typical feature of the development process. This transformation is however potentially very disruptive since it requires the reallocation of both people and resources across time, sectors and activities. While there has been a lot of work on understanding the flow of productive resources across sectors during these episodes, their effects on the relative fortunes of the people at the center of this transformation is somewhat less analyzed. Put differently, the work on structural transformation has mostly focused on the adjustment of quantities. Their effects on prices of goods and wages in different sectors and locations hasn't typically been a focus of attention. In this paper we fill this gap in the context of the experiences of China and India since the 1980s, a period in which both countries have been undergoing rapid structural transformation. Given that upwards of 1.5 billion people still reside in rural China and India combined (which is almost a fifth of the world population), the scale of the disruption and reallocation unleashed by this process is potentially massive with attendant implications for overall inequality in the two countries.

The paper introduces two main innovations. First, we explicitly inject locations into the analysis of structural transformation by distinguishing between rural and urban locations. This is in contrast to the standard approach which typically conflates agricultural activities with rural locations on the one hand, and non-agricultural activities with urban locations on the other. As we show empirically and quantitatively, this conflation can be misleading both as a physical description as well as for understanding the consequences of the process for the relative fortunes of people living in these locations. Second, the paper focuses not just on quantity movements but also on prices during this process by examining the changes in wages by sector and location as well as the relative sectoral prices of goods.

Our data analysis reveals some interesting contrasts between China and India. While both countries have exhibited similar patterns of structural transformation accompanied by rising urbanization, the movements in wages have been very different. Between 1988 and 2008 the mean wage gap between rural and urban workers in China has widened by 21 percentage points with the median gap widening by an even larger 24 percentage points.[1] In contrast, the mean urban-rural wage gap in India between 1983 and 2010 declined by 35 percentage points while the corresponding median wage gap contracted by a massive 66 percentage points. Somewhat puzzlingly, we find that individual worker attributes account for only a small fraction of the movements in wages. Interestingly, the contrasting urban-rural wage movements in the two countries have occurred in the backdrop of similar qualitative movements in the inter-sectoral wage gaps as well as in the relative sectoral prices of goods. This evidence suggests to us that the conflation of sectors and locations is not an innocuous abstraction.

To explain the contrasting trends in the urban-rural wage gaps in the two countries, the paper formalizes a two-sector, two-location overlapping generations model of structural transformation.

[1] Similar increases in inequality in China have been documented by Wu and Perloff (2005) for overall income and by Qu and Zhao (2008) for consumption.

Our model generates structural transformation due to non-homothetic preferences and growth in agricultural productivity. This is a familiar channel in the literature. The new part is that we also allow individuals to choose, through migration, their location of residence and work during their adult working years. Consequently, the model generates structural transformation and urbanization as a joint endogenous response to sectoral productivity shocks.

Locations in our model are distinguished by three features: amenities, sectoral productivities and costs of worker training. In our baseline environment, different locations provide different amenities which affect the utility of their residents. However, these amenities are also subject to congestion externalities that depend on the magnitude of migrants into that location. Our formalization of this externality is broad enough to also allow for policy-induced disincentives to migration across locations, such as the Hukou system in China. In an extension of the model, we also introduce agglomeration economies in production that depend positively on the magnitude of local labor force growth.[2]

Productivity shocks in the model have two effects on wages in urban and rural areas. On the one hand, the non-homotheticity induces a differential *demand-side effect* with demand for agricultural goods declining in relative terms. This lowers the relative wage in agriculture. With rural areas being predominantly agricultural, this tends to make the urban-rural wage gap larger. On the other hand, the productivity shock also induces migration of workers from rural to urban locations. The magnitude of the rural-to-urban migration depends both on the size of the wage gap as well as the induced congestion effects of migration on urban amenities. The direct effect of the migration-induced increase in the relative supply of urban labor is a fall in the urban-rural wage gap. We refer to this as the *urbanization effect*.[3] The end effect on the cross-location wage gap depends on the relative strengths of these effects which, in turn, depends on the relative strengths of the productivity shocks in the two sectors.

We calibrate the model to China and India separately and examine its quantitative predictions for both structural transformation and wage gaps by feeding in the measured changes in sectoral productivity during the sample period. For both China and India, the productivity shocks account for the structural transformation as well as most of the observed movements in the wage gaps that cannot be explained by individual worker attributes. In addition, the model also generates the rise in the relative price of agricultural that is a feature of the data in both China and India during this period. This is an important result because standard models of structural transformation with non-homotheticities predict the opposite. Overall, we view the results as being supportive of the model and the key mechanisms formalized in it.

Counterfactual experiments on the model suggest that a key factor behind the widening wage

[2]Our modeling of congestion and production externalities in different locations borrows from the literature on economic geography. However, we abstract from the sources of these externalities and instead simply assume that they depend on the size of the local population. This simplification allows us to focus on the effect of the externalities of migration on the locational distribution of production. An extensive discussion on the microfoundations of these externalities can be found in the works of Lucas and Rossi-Hansberg (2002) and Duranton and Puga (2004). Our modeling approach is similar in spirit to the work of Allen and Arkolakis (2014).

[3]Furthermore, in the presence of agglomeration economies on production, the increase in the urban labor force also raises urban productivity. This tends to widen the urban-rural wage gap. We quantitatively examine the effect of this channel in an extension of the baseline model.

gap in China is the restriction on migration within the country. We find that lowering the implied migration restrictions in China to the corresponding levels in India would generate a sharp 32 percentage point contraction in the wage gap in China along with an additional 9 percentage point decline of the rural share of the workforce between 1988 and 2008. Our model also suggests that had agricultural and non-agricultural productivities in India grown at the significantly faster rates observed in China, India would have seen the urban-rural wage gap decline by an additional 5.3 percentage points while the urban share of the labor force would have grown to 33 percent by 2010 rather than the 30 percent in the data.

Lastly, we test the basic mechanisms formalized in the model using cross-province data in China and cross-state evidence in India. As predicted by our model, we find that for a given urban share of the workforce, places with higher productivity growth have a larger urban-rural wage gap. This is the demand effect of productivity growth that our model (as well as most models of structural transformation) emphasized. On the other hand, we also show that, controlling for productivity growth, locations with greater urban employment shares have smaller urban-rural wage gaps. This is evidence for the supply-side effect of a rising urban workforce that the model's endogenous migration channel emphasized. We view these results as confirmation for the mechanisms formalized by the model.

We should note that our mechanism for generating structural change relies on a lower income elasticity of demand for agricultural goods due to non-homotheticity in preferences as formalized in Laitner (2000), Kongsamut, Rebelo, and Xie (2001), Gollin, Parente, and Rogerson (2002) amongst others. An alternative mechanism that has been proposed in the literature (dating back to Baumol (1967)) relies on differential sectoral productivity growth. In particular, Ngai and Pissarides (2007) use a multi-sector model to show that as long as the elasticity of substitution between final goods is less than unity, over time factors would move to the sector with the lowest productivity growth. In both China and India this mechanism leads to a counterfactual implication. Since productivity growth in non-agriculture was faster than in agriculture, the Ngai and Pissarides (2007) mechanism would imply that factors should have migrated to the agricultural sector over time while the data shows the opposite. One could get around this by assuming that the elasticity of substitution between final goods is greater than unity. However, given the lack of precise estimates on this elasticity, it seems heroic to put the entire onus of the explanation on the configuration of a poorly measured parameter. Consequently, we shut down this channel by assuming that the elasticity of substitution between final goods is unity. This also implies that the reasons for structural transformation in the model are the non-homotheticity in preferences.[4]

There has been a renewed interest in understanding spatial wage and income differentials recently. This literature has proposed two main explanations for the spatial differentials. The first argues that they are caused by misallocation of labor across locations due to migration costs, incomplete markets,

[4] Our work is also related to the factor deepening channel for structural transformation formalized in Acemoglu and Guerrieri (2008). Another possible channel is the skill acquisition cost mechanism proposed by Caselli and Coleman (2001) in their study of regional convergence between the North and South of the USA. In their model a fall in the cost of acquiring skills to work in the non-agricultural sector induces a fall in farm labor supply and leads to an increase in farm wages and relative prices. An overview of this literature can be found in Herrendorf, Rogerson, and Valentinyi (2013a).

and migration risk. Thus, Morten (2016) and Munshi and Rosenzweig (2016) show that the potential loss of village insurance networks constitutes an important cost of migration from rural to urban areas in India. Bryan and Morten (2016) evaluate the contribution of migration costs to the spatial wage differences in Indonesia. In addition, migration costs often take a form of direct policy restrictions on labor moving from rural to urban locations – e.g., the Hukou system in China.

The second explanation is based on the idea that spatial wage gaps are efficient, reflecting workers sorting across locations based on their observed and unobserved characteristics, or differential utility from residing in urban or rural areas. For instance, Young (2012) finds that workers in urban areas tend to have more education. Similarly, Hnatkovska and Lahiri (2015) show that rural-to-urban migrants in India tend to be younger and more educated than nonmigrants. These observations suggest that workers' sorting is an important contributor to urban-rural wage gaps.

Our work contributes to this literature in several respects. First, our analysis carefully differentiates the spatial and sectoral gaps in wages and labor allocations. Indeed, in the data we show that both locational and sectoral differences in wages and labor allocations significantly contribute to the overall distribution of wages and workforce in China and India.[5] This is in stark contrast to most of the literature which focuses on the sectoral dimension of the transformation. Examples of this "sectoral" approach can be found in Herrendorf and Schoellman (2015), Lagakos and Waugh (2012) and Gollin, Lagakos, and Waugh (2012).

Second, our focus is on the implications of aggregate shocks for the evolution of locational wage differentials. Since our empirical results showed that a majority of the urban-rural wage gap is left unaccounted for by worker characteristics, our modeling goal is to explain the part of the wage gap that *cannot* be explained by worker characteristics. In order to do this we abstract from any individual-specific differences in terms of skills or endowments. Importantly, the absence of worker heterogeneity in skills or ability in our model eliminates explanations based on worker sorting of the kind emphasized in Young (2012). Those should be viewed as complementary to the explanation we propose.

Third, the existing literature has focused on explaining spatial wage differentials at a point in time. Our work extends this analysis to add a time-series perspective on spatial wage gaps. Studying the evolution of rural-urban wage gaps over time not only allows us to better identify the factors behind the gaps, but also impose more discipline on the structural model as we require the implications of such a model to be consistent with both the spatial wage differentials at a point in time and with the dynamic evolution of these gaps in response to aggregate economic developments. Indeed, this time series dimension of the model provides an independent, over-identifying test of the model.

The rest of the paper is organized as follows: the next section presents the data and the main

[5] The disinction between locational and sectoral reallocation of factors shows up both in the data and in the policy initiatives within countries. In both China and India there is evidence of rural workers moving from agriculture into non-agriculture within rural areas. Indeed, a non-trivial share of the structural transformation in these economies occurs through workers switching sectors within the same location. Consequently, one finds a significant share of rural workers engaged in non-agricultural work even though non-agricultural productivity and wages are significantly higher in urban areas. On the policy front, India has initiated one of the largest public works programs globally called the National Rural Employment Guarantee Scheme (NREGA). The program guarantees 100 days work to every rural worker. The policy is a response to a perceived concern that the market mechanism was not effective in generating sufficient urban, non-agricultural employment for workers switching out of agricultural work in rural areas.

results on rural-urban gaps and their changes over time, as well as the analysis of the extent to which these changes were due to changes in individual characteristics of workers. Section 3 presents our model and examines the role of aggregate shocks in explaining the patterns. In section 4 we present some analytical results while section 5 presents the quantitative results. The last section contains concluding thoughts.

2 Empirical results

Our primary data source for China is the Chinese Household Income Project (CHIP). We use five rounds of the CHIP (1988, 1992, 1995, 2002 and 2008). Since our interest is in determining the trends in wages and determinants of wages such as education and occupation, we choose to restrict the sample to individuals in the working age group 16-65 who are identified as working and who report working at least 1900 hours per year. These restrictions leave us with 47,000 to 83,000 individuals per survey round. The data for India comes from successive rounds of the Employment & Unemployment surveys of the National Sample Survey (NSS) of households in India. The survey rounds that we include in the study are 1983, 1993-94, 1999-2000, 2004-05, and 2009-10.[6] We restrict the sample to individuals in the working age group 16-65, who are working full time (defined as those who worked at least 2.5 days in the week prior to being sampled), who are not enrolled in any educational institution, and for whom we have both education and occupation information. We further restrict the sample to individuals who belong to male-led households.[7] These restrictions leave us with about 140,000 to 180,000 individuals per survey round. Details on our data are provided in Appendix A.1.

Our primary focus is on real wages. For China, we use annual wage income which are deflated using province-level CPI deflators that differ for rural and urban sectors. For India we measure wages as the daily wage/salaried income received for the work done by respondents during the previous week (relative to the survey week), if the reported occupation during that week is the same as worker's usual occupation (one year reference).[8] Wages can be paid in cash or kind, where the latter are evaluated at current retail prices. We convert wages into real terms using state-level poverty lines that differ for rural and urban sectors.[9] We express all wages in 1983 rural Maharashtra poverty lines.

We start by computing the wage gaps between urban and rural workers in China and India.[10]

[6] There is also a survey round for 1987-88, but we did not include it in our analysis as the number of observations for wages in this round falls dramatically relative to the other rounds. This decline is mainly accounted for by the drop in the rural wage observations.

[7] This avoids households with special conditions since male-led households are the norm in India.

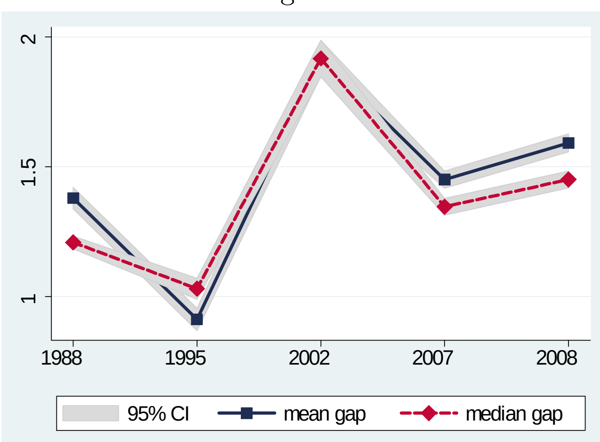
[8] This allows us to reduce the effects of seasonal changes in employment and occupations on wages.

[9] In 2004-05 the Planning Commission of India changed the methodology for estimation of poverty lines. Among other changes, they switched from anchoring the poverty lines to a calorie intake norm towards consumer expenditures more generally. This led to a change in the consumption basket underlying poverty line calculations. To retain comparability across rounds we convert the 2009-10 poverty lines obtained from the Planning Commission under the new methodology to the old basket using a 2004-05 adjustment factor. That factor was obtained from the poverty lines under the old and new methodologies available for the 2004-05 survey year. As a test, we used the same adjustment factor to obtain the implied "old" poverty lines for the 1993-94 survey round for which the two sets of poverty lines are also available from the Planning Commission. We find that the actual old poverty lines and the implied "old" poverty lines are very similar, giving us confidence that our adjustment is valid.

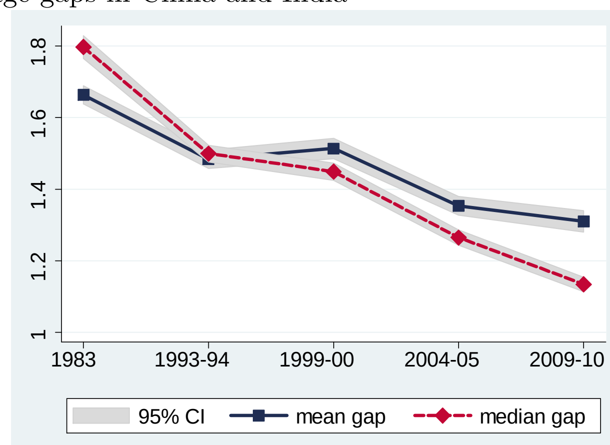
[10] The wage gaps are obtained from a regression of (log) wages on age, age squared and a rural dummy. The

Panel (a) of Figure 1 shows the mean and median gaps for China while Panel (b) shows the corresponding gaps for India. Shaded areas represent 95% confidence intervals. The panels present a striking contrast: both the mean and the median urban-rural wage gaps widened in China between 1988 and 2008 while they narrowed in India between 1983 and 2010. Specifically, in China, the mean urban-rural wage gap increased from 38% in 1988 to 59% in 2008 – a 21 percentage points rise. In India, on the contrary, the mean urban-rural gap declined from 66% in 1983 to 31% in 2010 – a 35 percentage points decline. The changes in median wages were even more pronounced in both countries. The median urban wage premium in China increased from 21% in 1988 to 45% in 2008 – a 24 percentage points rise; while it declined from 80% to 13% in India – a stunning 66 percentage points fall. Thus, we observe divergence in urban and rural wages in China, but a convergence in India over the past 30 years.

Figure 1: The urban-rural wage gaps in China and India



(a) China



(b) India

Notes: Panel (a) shows the mean and median urban-rural wage gaps for China, while Panel (b) shows the same wage gaps for India. These are obtained from a regression of (log) wages on a rural dummy, age, and age squared. Shaded areas are 95% confidence intervals.

The urban-rural wage gap could arise due to either the urban-rural gap being large within each sector (Agriculture or Non-agriculture, in our case), or due to between-sector gaps within each location (rural and urban, in our case) being large. Table 1 reports such conditional wage gaps in the two countries. It highlights an important difference between China and India. In the case of China the major source of the large urban mean wage premium was the high urban-rural wage gap *within each sector* whereas in India the big contributor was the *between-sector* gap in each location. Moreover, these gaps also evolved differently over time in the two countries. In China, the divergence between rural and urban wages was driven by the divergence of urban-rural gaps within each sector; while in India, the urban-rural wage convergence was primarily due to shrinking sectoral gaps in each location. These patterns emphasize the importance of distinguishing sectors and locations in the analysis.

reported wage gaps are exponents of -1 times the coefficient on the rural dummy. Mean gaps are obtained from the OLS regressions, while median gaps are obtained from the Recentered Influence Function (RIF) regressions (see Firpo, Fortin, and Lemieux (2009) for more details on the latter).

Table 1: Employment shares and wage gaps

	China		India	
	1988	2008	1983	2010
employment shares:				
L_U	0.26	0.35	0.22	0.30
L_{RA}/L_R	0.79	0.66	0.78	0.66
L_{UA}/L_U	0.05	0.03	0.11	0.07
wage gaps:				
within A	1.844	2.557	0.934	1.027
	(0.080)	(0.375)	(0.018)	(0.042)
within N	1.289	1.583	1.082	0.994
	(0.020)	(0.018)	(0.012)	(0.014)
R between	1.285	1.238	1.962	1.679
	(0.051)	(0.083)	(0.022)	(0.019)
U between	0.984	0.751	2.259	1.709
	(0.020)	(0.088)	(0.050)	(0.069)
overall mean	1.379	1.591	1.664	1.310
	(0.021)	(0.018)	(0.013)	(0.015)

Note: Numbers in parenthesis are standard errors.

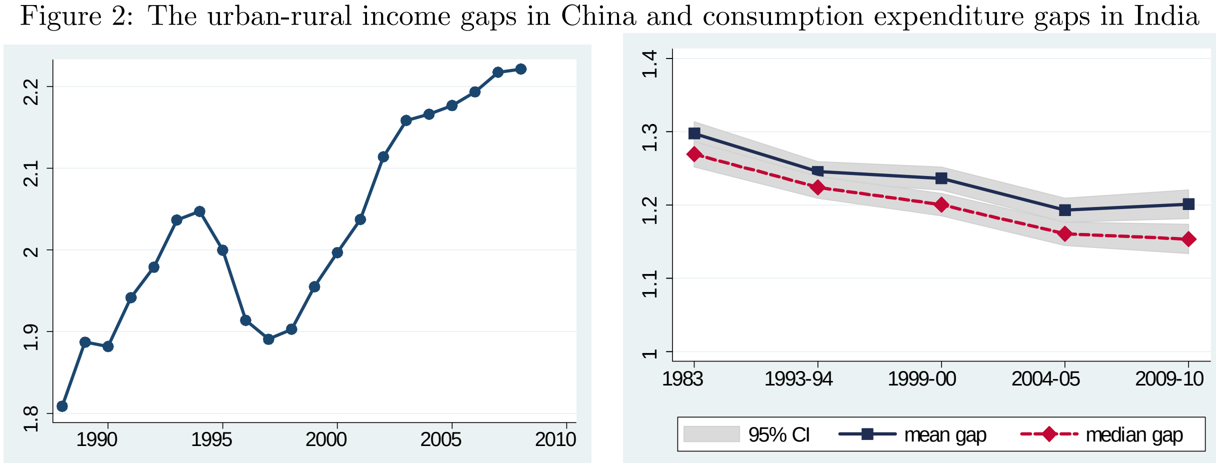
Table 1 highlights another important reasons for our focus on urban-rural gaps as opposed to just inter-sectoral gaps. The top panel of that table reports employment shares of agriculture in each location. It makes it clear that in both China and India, the period since the 1980s has been accompanied by an increase in the share of the rural labor force engaged in non-agricultural activities. Thus, $\frac{L_{RA}}{L_R}$ fell from 0.79 to 0.66 in China while it fell from 0.78 to 0.66 in India during the period under study. In effect, the share of the rural labor force engaged in non-agricultural activities in these two countries rose from just under 1/4 to around 1/3. Clearly, movement of factors from agriculture to non-agriculture is not isomorphic with movement of factors from rural to urban areas.

2.1 Robustness of wage patterns

A potential concern with the wage patterns documented above is that they may not be representative of the overall patterns in urban-rural *income* gaps since a significant proportion of rural workers tend to be self-employed and, therefore, do not report any wage income. We examine robustness of our data findings to this issue by using two supplementary checks. First, we examine the relative share of self-employed workers in the urban and rural labor forces to uncover any systematic trends. Differential trends in the relative proportions of self-employed in urban and rural areas could potentially induce trends in wage gaps simply through a composition effect even if the underlying wage gaps remained unchanged. We find that in India, the share of self-employed in the urban labor force is lower than in rural areas. However, there are no systematically differential trends in these shares over time with the urban share fluctuating around 40 percent and the rural share around 60 percent. In China, the share of self-employed in the urban labor force rose from 1.2 percent to 8.8 percent while the corresponding rural share rose from close to zero in 1988 to 7.4 percent in 2008. Thus, in neither country do we find systematic differences in the dynamics of urban and rural incidence of self-employment.

Second, to check whether the wage patterns carry over to broader measures of income, we also consider family income in China (which consists of wage income and other non-wage sources of income) and household consumption expenditures in India (which is a proxy for family income that includes both wage and self-employed income). Both variables are in real per capita terms.[11] Panel (a) of figure 2 reports the mean gaps in annual family income between urban and rural households in China using the China Statistical Yearbook, while panel (b) shows the mean and median urban-rural gaps in per capita monthly consumption expenditures in India using NSS data. These figures confirm our findings for wages. In China, urban family income, much like wage income, has diverged from rural family income over time with income gaps rising more sharply than wage gaps. In contrast, in India, consumption expenditures in urban and rural families have been converging over time, although the convergence is more muted than the convergence in wages. This is not surprising given that the consumption expenditure gaps are smaller to start with and since consumption habits also tend to adjust slowly over time.[12]

Figure 2: The urban-rural income gaps in China and consumption expenditure gaps in India



(a) family income in China

(b) household cons. expenditures in India

Notes: Panel (a) shows the urban-rural per capita family income gaps in China using China Statistical Yearbook data, while panel (b) shows the urban-rural per capita consumption expenditure gaps for India using NSS data. The income gaps are obtained as -1 times the exponents of coefficients on the rural dummy from OLS regression of (log) consumption expenditures on a rural dummy. The consumption gaps are obtained in the same way, (also using RIF regression to get median gaps) except the regressions also include the household size to account for possible scale effects in household consumption.

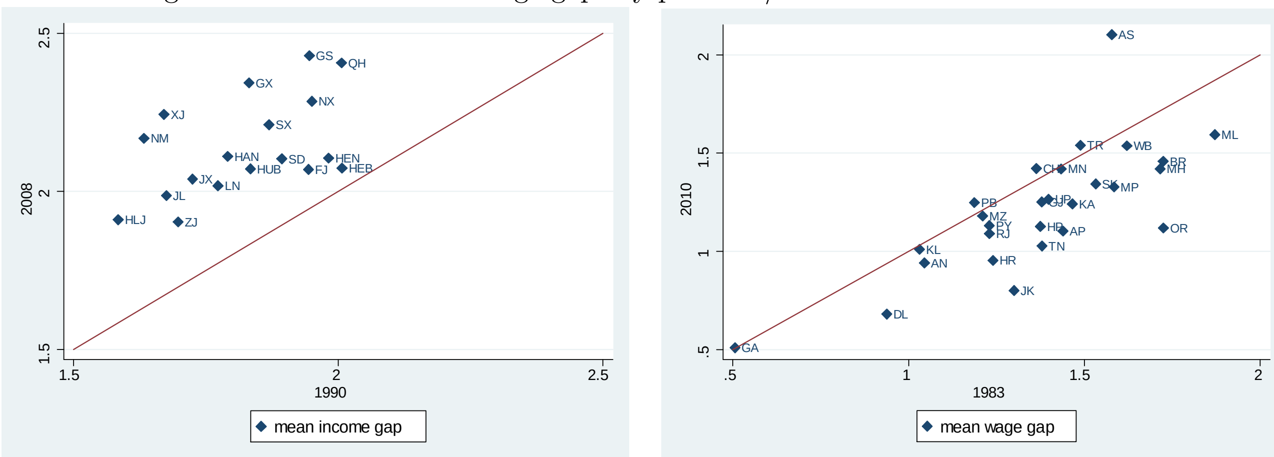
A different concern about the wage and income patterns documented above is that they may be driven by some outlier provinces or states. Panel (a) of Figure 3 plots the scatter of the urban-rural income gaps across provinces in China for 1990 and 2008, while Panel (b) plots the scatter of urban-rural wage gaps for states in India for 1983 and 2010. The key feature to note is that most of the points for China lie above the 45 degree line indicating larger gaps in 2008 relative to 1990. The corresponding scatter of points for Indian states lie primarily below the 45 degree line indicating a narrowing of the wage gap between urban and rural workers between 1983 and 2010. Thus, income

[11] Family income in China is annual income, while consumption expenditures in India are monthly expenditures.

[12] Another concern regarding the robustness of the wage patterns shown in Figure 1 is that while the NSS data for India is a nationally representative sample, the CHIP data for China is not nationally representative as it contains data for households from only nine provinces. The data from China Statistics Yearbook covers all provinces.

divergence in China and wage convergence in India seem to be taking place across-the-board.

Figure 3: The urban-rural wage gaps by province/state in China and India



(a) China (b) India

Notes: Panel (a) shows the urban-rural wage gaps for provinces in China for 1990 and 2008. Panel (b) shows the urban-rural wage gaps for India for 1983 and 2009-10 NSS rounds.

We view these results as suggestive of the robustness of the basic fact that the urban-rural wage gap widened in China between 1988 and 2008 while it declined in India between 1983 and 2010.

2.2 Explaining the trends

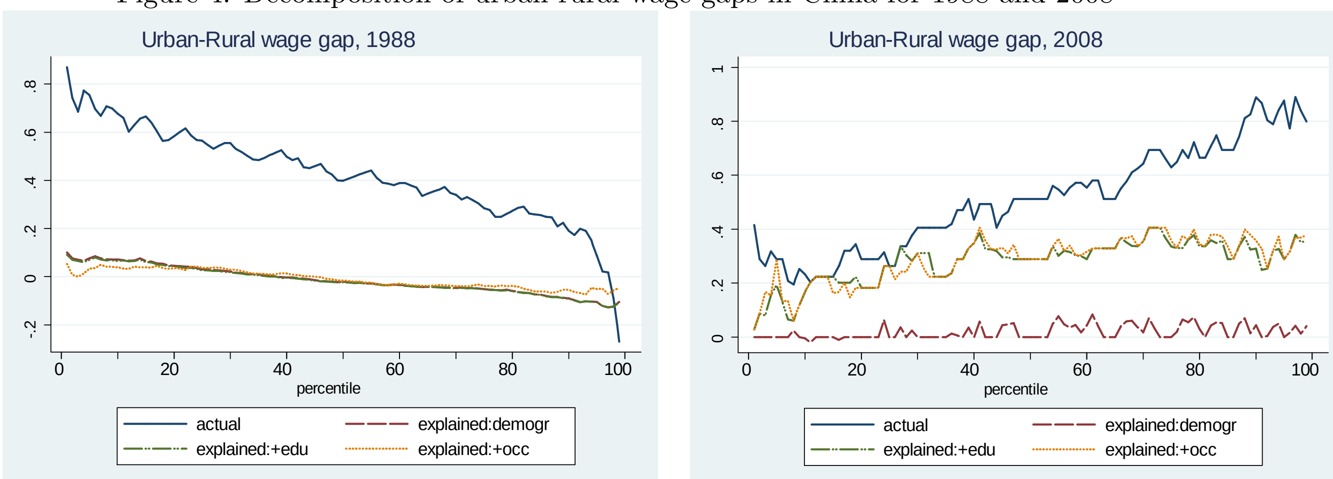
What explains the observed patterns in the urban-rural wage gaps in the two countries? The standard explanations focus on measured attributes in wages such as demographics, education, occupation, etc.. How much of the wage convergence/divergence documented above is driven by a convergence/divergence of measured covariates? We examine this using a procedure developed by DiNardo, Fortin, and Lemieux (1996) (DFL from hereon) to decompose the difference in the observed wage distributions of urban and rural labor within a sample round into two components – the part that is explained by differences in attributes and the part that is explained by differences in the wage structure of the two groups. To obtain the explained part, for each set of attributes we construct a counterfactual density for urban workers by assigning them the rural distribution of the attributes.[13]

We consider several sets of attributes. First, we evaluate the role of individual demographic characteristics such as age, age squared, gender and geographic location. Second, we add education to the set of attributes and obtain the incremental contribution of education to the observed wage convergence. Lastly, we evaluate the role played by differences in the occupation distribution for the urban-rural wage gaps.

[13] The DFL method involves first constructing a counterfactual wage density function for urban individuals by giving them the attributes of rural households. This is done by a suitable reweighting of the estimated wage density function of urban households. We choose to do the reweighting this way to avoid a common support problem, i.e., there may not be enough rural workers at the top end of the distribution to mimic the urban distribution. The counterfactual urban wage density is then compared with the actual urban wage density to assess the contribution of the measured attributes to the observed wage gap.

Figure 4 presents our findings for China for 1988 (panel (a)) and 2008 (panel (b)). The solid line shows the actual urban-rural (log) wage gaps for the entire wage distribution, while the broken lines show the gaps explained by differences in attributes of the two groups, where we introduced the attributes sequentially. The plot for 1988 says that observed gaps in attributes explained very little of the actual wage gap in that year. In 2008 by contrast, measured attributes, especially education, explain almost 60 percent of the actual median gap with the explanatory power becoming smaller at the higher income percentiles. The two graphs combined suggest that a significant part of the overall movement in the wage gaps was unaccounted for by measured covariates of wages.

Figure 4: Decomposition of urban-rural wage gaps in China for 1988 and 2008

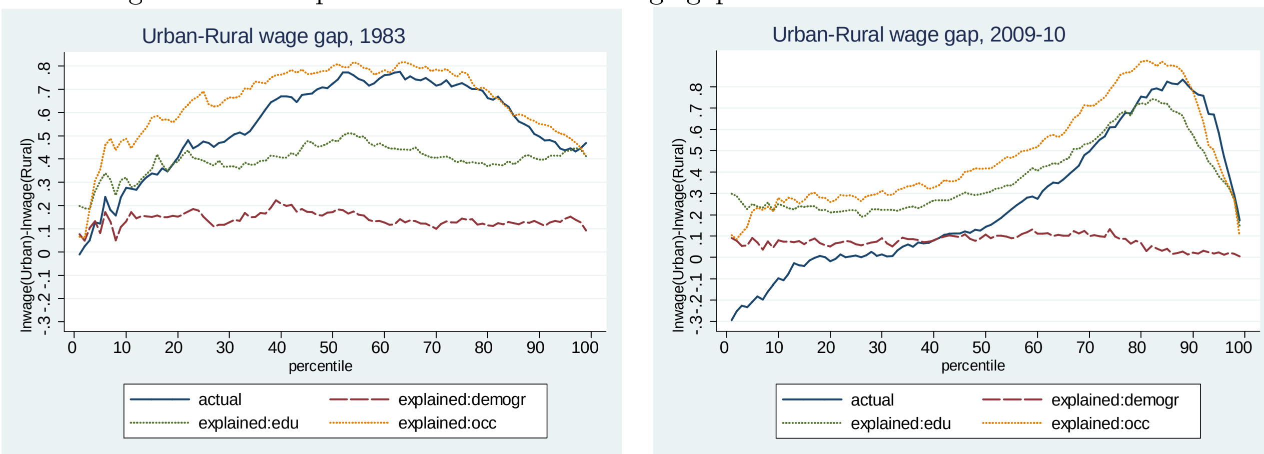


(a) China, 1988 (b) China, 2008

Notes: Each panel shows the actual log wage gap between urban and rural workers for each percentile, and the counterfactual percentile log wage gaps when urban workers are sequentially given rural attributes. Three sets of attributes are considered: demographic (denoted by "demogr"), demographics plus education ("edu"), and all of the above plus occupations ("occ"). The left panel shows the decomposition for 1988 while the right panel is for 2008.

Figure 5 plots the same graphs for India for 1988 (panel (a)) and 2009-2010 (panel (b)). Like in China, demographic characteristics explain a small fraction of the urban-rural wage gap. In 1983 differences in education account for almost the entire wage gap at the bottom of the distribution, while differences in occupation explain the wage gap for the upper 50 percent of the distribution. Put differently, education and occupation choices can jointly account for almost the entire wage gap distribution in India in 1983. In 2009-10 however, differences in education attainments between urban and rural workers explain a large fraction of the gap at the top end of the distribution (70th percentile and above). However, for those below the 70th percentile, covariates such as demographic characteristics, education and occupation choices systematically *over-predict* the actual wage gaps. This is particularly stark for the bottom 15 percent where the actual wage gap is negative while the demographic characteristics, education endowments and differences in occupations predict that the urban-rural gap should be positive 30 percent.

Figure 5: Decomposition of urban-rural wage gaps in India for 1983 and 2009-10



(a) India, 1983 (b) India, 2010

Notes: Each panel shows the actual log wage gap between urban and rural workers for each percentile, and the counterfactual percentile log wage gaps when urban workers are sequentially given rural attributes. Three sets of attributes are considered: demographic (denoted by "demogr"), demographics plus education ("edu"), and all of the above plus occupations ("occ"). The left panel shows the decomposition for 1988 while the right panel is for 2008.

These results suggest that a large part of the observed wage differences cannot be explained by standard covariates of wages. Hence, changes in the wage structure of urban and rural workers during the sample period have played an important role in driving the observed wage patterns.

3 The Role of Aggregate Shocks

The previous results suggest that a large part of the movement in the wage gap between rural and urban workers in China and India cannot be accounted for by the individual characteristics of the two groups. What then explains the trends? One possibility is that aggregate developments during this period may have played a role. Specifically, the period since the 1980s was marked by a sharp increase in the aggregate growth rate, structural transformation and rapid urbanization of the economy in both countries. Could these aggregate changes have contributed to the observed trends in rural-urban gaps in China and India? In this section we examine this possibility by exploring their effects through the lens of a structural model.

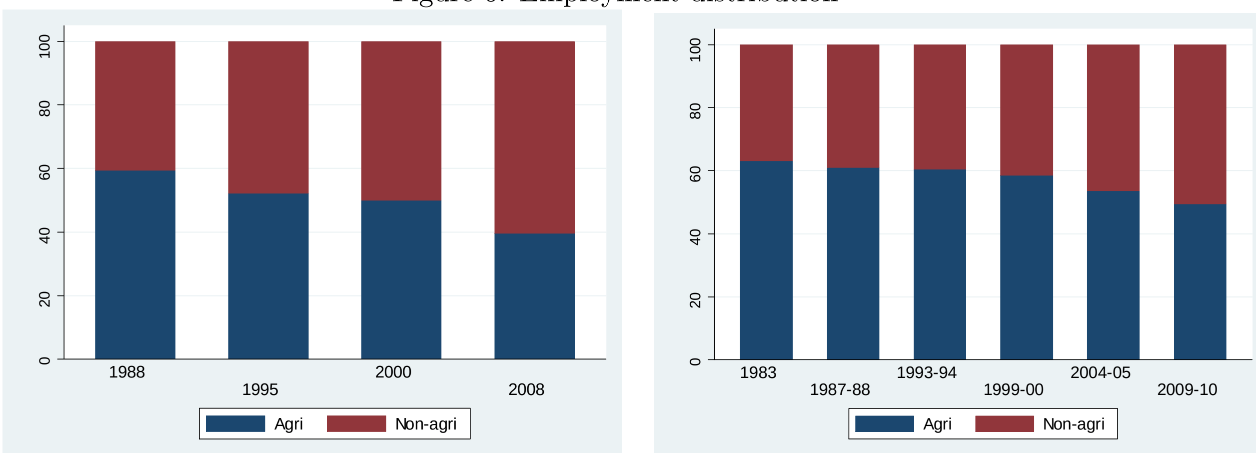
3.1 Aggregate facts

Before presenting the model it is useful to summarize some important aggregate developments in China and India over the last three decades. Our key aggregate facts relate to the structural composition of employment and output, sectoral productivities, the urban share of the labor force, and relative prices (see Appendix A.3 for data sources and computations). We want the model to be consistent with these facts.

The ongoing process of structural transformation of China and India can be seen through Figures

6 and 7. Figure 6 shows employment shares in agriculture and non-agriculture for China (panel (a)) and India (panel (b)). Figure 7 shows the distribution of output across the agriculture and non-agriculture in the two economies. As is easy to see, agriculture has been releasing workers in both countries, and its share of output has also been declining over time in both India and China. These are the textbook features of structural transformation.

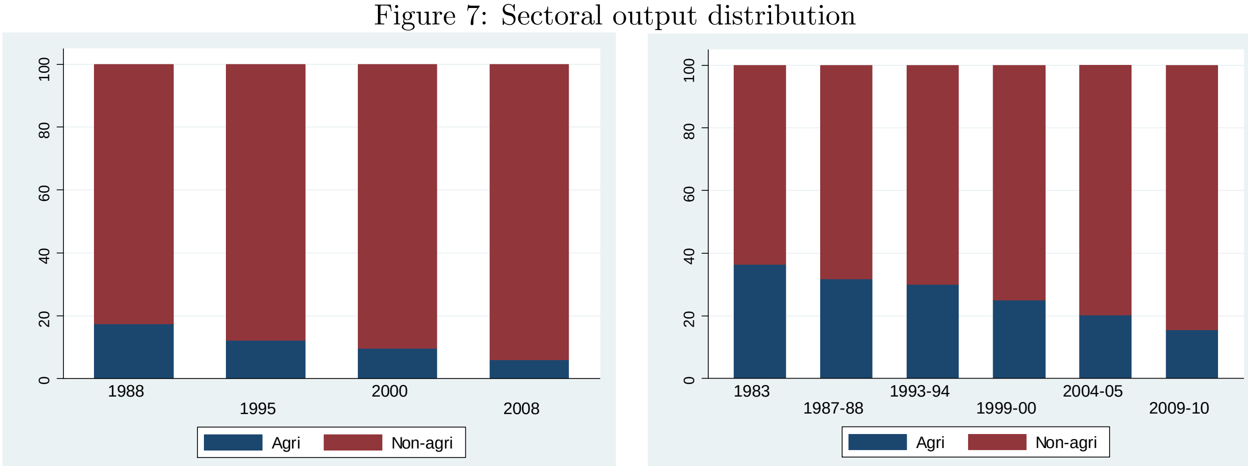
Figure 6: Employment distribution



(a) China: employment shares (b) India: employment shares

Notes: Panel (a) of this Figure presents the distribution of workforce across agricultural and non-agricultural sectors for China while panel (b) presents the employment distribution across the two sectors for India.

Figure 7: Sectoral output distribution

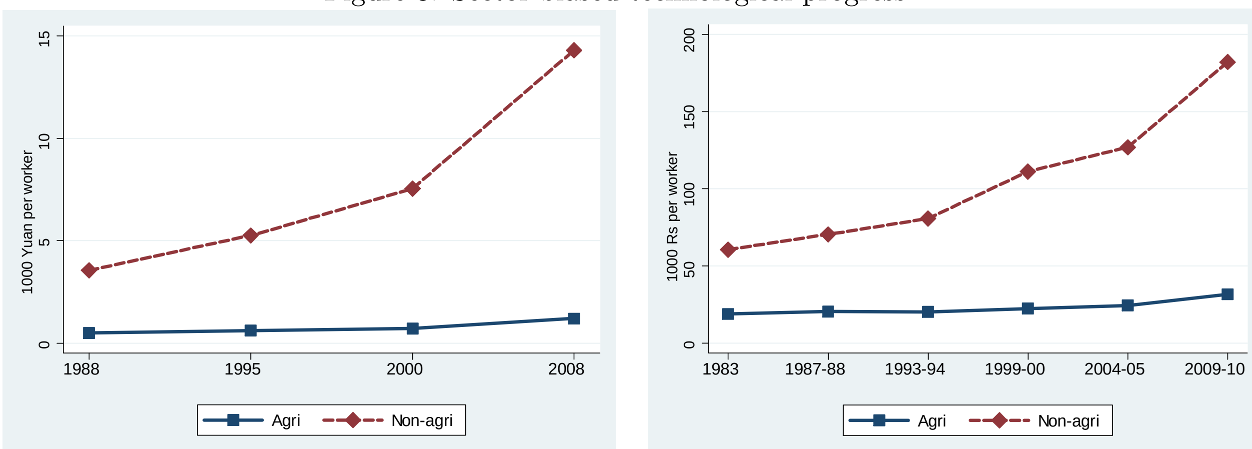


(a) China: output shares (b) India: output shares

Notes: Panel (a) of this Figure presents the distribution of output across agricultural and non-agricultural sectors in China. Panel (b) presents same distribution for India.

The third aggregate fact of interest is the behavior of sectoral labor productivities in the two countries during this period. Figure 8 shows that in both China and India, labor productivity in both agriculture and non-agriculture was increasing during this period, with non-agricultural productivity expanding at a much faster pace. While the patterns in the two economies were remarkably similar, a key difference was that labor productivity growth in China was must faster than in India. Thus, the labor productivity in agriculture increased by only 67 percent in India between 1983 and 2010. In contrast, agricultural labor productivity in China grew by 163 percent between 1990 and 2008. The non-agricultural labor productivity rose by 200 percent in India and 338 percent in China during the same periods.[14]

Figure 8: Sector-biased technological progress



(a) China (b) India

Notes: Panel (a) shows sectoral labor productivity during the 1990-2008 period for China, while panel (b) shows the same for India for the 1983-2010 period.

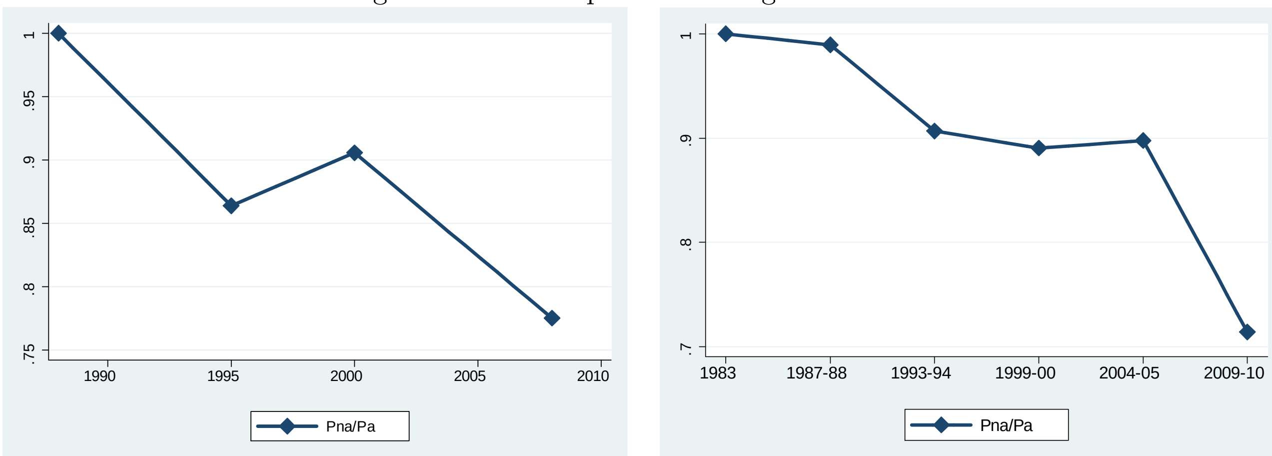
Next, Figure 9 presents the evolution of the relative price of non-agricultural goods (relative to agricultural good) in China and India since the 1980s. The movement in this relative price is very similar in the two countries. The relative price of non-agriculture declined by 23 percent in China and 29 percent in India. It is worth noting that the world relative price of agriculture was actually falling during most of the period since the 1980s, in contrast to the rising relative price of agriculture in China and India.

The final key aggregate fact relates to urbanization. Figure 10 shows the urban share of both population and employment in China (panel (a)) and India (panel (b)) during their sample periods of 1988-2008 and 1983-2010, respectively. Just as in patterns on relative prices and structural transformation, the urbanization patterns are qualitatively very similar in the two countries with the urban share of employment rising from 26 to 35 percent in China and 22 to 30 percent in India.

Our main takeaway from these aggregate facts in China and India is that the patterns of structural transformation, sectoral productivity growth, urbanization and relative price movements were all very similar qualitatively. However, there were quantitative differences in the changes, especially in sectoral productivity growth and the size of the structural transformation. These facts, therefore, raise a question of whether similar aggregate dynamics in the two countries can be simultaneously

[14]When reporting growth rates of labor productivity we used 1990 as the starting year for China instead of 1988 because of discountinuity in the sectoral employment data for China in 1989. We suspect that the definition of employed must have been changed in that year.

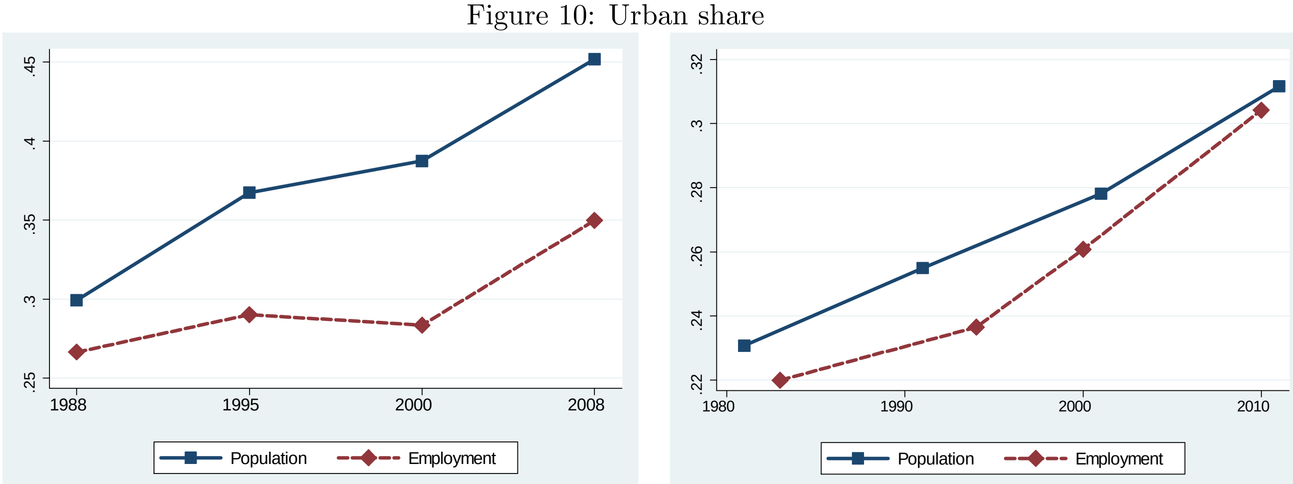
Figure 9: Relative price of non-agriculture



(a) China (b) India

Notes: This figure shows the price of non-agricultural output relative to agricultural output. The relative price in the initial sample year is normalized to 1.

Figure 10: Urban share



(a) China (b) India

Notes: This figures show the urban share of population and employment.

consistent with the expanding wage gaps in China but contracting wage gaps in India. We answer it with a calibrated structural model.

3.2 A Structural Explanation

We formalize a simple model with two sectors (agriculture and non-agriculture) and two locations (rural and urban). The goal of the exercise is to structurally identify the minimal features that can generate the key facts characterizing the Indian economy during 1983-2010 and the Chinese economy during 1988-2008 period, as outlined above: (i) a structural transformation; (ii) rising urbanization; (iii) changing urban-rural wage gaps; and (iv) an improvement in the agricultural terms of trade. We then quantitatively examine the relative contributions of the identified factors to the observed wage convergence in India and wage divergence in China.

Consider an economy with two locations: rural and urban. Each location produces two goods – an agricultural good and a non-agricultural good. Under our formalization, locations are defined by three key distinguishing characteristics: (a) their productivities in producing the two goods; (b) the amenities they provide for their residents; and (c) the cost of training workers in each location. We elaborate on these below.

We assume that goods markets are integrated in this economy so that the price of each good is equalized across locations. However, labor mobility across locations is costly. Hence, factor markets are segmented across locations at any point in time implying that factor prices can also differ across locations. We assume throughout that there is no uncertainty in this economy so that we shall focus on equilibria with perfect foresight.

3.3 Technology

The location-specific technologies for producing the two goods are

$$Y_t^{jA} = A_t^j \left(L_t^{jA} \right)^{\alpha^j}, \qquad j = R, U \tag{3.1}$$

$$Y_t^{jN} = N_t^j \left(L_t^{jN} \right)^{\beta^j}, \qquad j = R, U \tag{3.2}$$

where $\alpha^j \in (0,1)$ and $\beta^j \in (0,1)$. Throughout the paper we shall use R to denote rural and U to denote urban. L^{jA} denotes total employment of labor in the agricultural sector in location $j = R, U$. Similarly, L^{jN} denotes total employment of labor in the non-agricultural sector in location $j = R, U$. Note that underlying these decreasing returns to labor technologies is a fixed factor like land. A^j and N^j denote the total factor productivity in location $j = R, U$ in the agricultural and non-agricultural sectors, respectively. Note, that we allow the sectoral productivities to be different across location. Indeed, this is one of the key aspects distinguishing locations in the model.

Competitive firms in each location and sector hire labor to maximize profits. Consequently,

$$w_t^{jA} = \alpha^j \frac{Y_t^{jA}}{L_t^{jA}}, \qquad j = R, U \tag{3.3}$$

$$w^{jN} = \beta^j \frac{p_t Y_t^{jN}}{L_t^{jN}}, \qquad j = R, U \tag{3.4}$$

where w^{jA} denotes the real wage in location j in the agricultural sector while w^{jN} is the real wage in location j in sector N. p is the relative price of the non-agricultural good in terms of the agricultural good, which we treat as the numeraire good throughout. Clearly, profits of firms then are

$$\Pi_t^{jA} = \left(1 - \alpha^j\right) Y_t^{jA} \tag{3.5}$$

$$\Pi_t^{jN} = \left(1 - \beta^j\right) p_t Y_t^{jN} \tag{3.6}$$

These are the returns to the fixed factor.

3.4 Households

Each location is inhabited by overlapping generations of two-period lived individuals. In the first period of life each individual chooses the location where she wants to live next period. Changing locations however is costly. Young individuals who choose to change their location have to pay τ units of the agricultural good as a relocation cost. These relocation costs can be financed through borrowing in domestic capital markets. In the second period of life individuals work in the location they chose when young, have children, repay their debts (if any), consume and then die. Each worker in location $j = R, U$ at date t has 1 kid so that population is constant in this economy over time.[15]

In the second period of their lives, individuals have an endowment of one unit of time which they supply inelastically to the labor market in their location of residence. Labor time supplied to the agricultural sector is productive directly. Labor time supplied to the $N-$sector however requires some sectoral training which entails a cost τ^j units of the agricultural good per unit of labor time. Note that we are allowing the labor training costs to be location specific, since $j = R, U$.

Individuals derive utility from consumption only when old. Hence, lifetime utility of an individual born at date t in location i and who chooses to work and consume in location j at date $t+1$ is

$$V_t^{ij} = u\left(c_{t+1}^{ij}\right)\varepsilon_{t+1}^{j}, \quad u' > 0,\ u'' < 0$$

where

$$c_t^{ij} = \left(c_t^{ijA} - \bar{a}\right)^{\theta}\left(c_t^{ijN} + \bar{n}\right)^{1-\theta}, \quad i = R, U,\ j = R, U$$

c^{ij} denotes consumption of an individual born in location i and consuming in location j. $\bar{a}$ denotes the minimum consumption level of the agricultural good and $\bar{s}$ is the minimum level of the non-agricultural good that is produced at home. This is a standard method of introducing non-homotheticity into the model which makes the income elasticity of demand for the agricultural good less than the corresponding income elasticity of the non-agricultural good.

ε^j is a term reflecting the level of amenities available in location $j = R, U$. It is exogenous to the individual, and identical for all agents in location j. We shall assume that

$$\varepsilon_t^j = \bar{\varepsilon}^j e\left(M_t^j, L_t^{jj}\right), \quad j = R, U \tag{3.7}$$

where M_t^j denotes the number of migrant workers in location j at date t and L_t^{jj} denotes the total number of workers in location j at date t who were also born in location j. $\bar{\varepsilon}^j$ is a location-specific constant scalar. The function $e(.,.)$ captures externalities that could arise from new migrants into

[15] Our formalization of the migration decision as a dynamic choice is aimed at capturing long-term migration. We could potentially allow within-period, short-term migration as well by having workers change locations after observing the locational productivities for the period and paying for the migration cost out of their current period wage earnings. This would not change the theoretical logic of the model. We choose to abstract from this margin since a large part of these short-term flows tend to reverse themselves within a year as opposed to the long term migration flows that contribute to the growing urbanization of the economy.

the location as well as the size of the location. We shall specialize this function as

$$e\left(M_t^j, L_t^{jj}\right) = \left(1 + \frac{M_t^j}{L_t^{jj}}\right)^{\phi}, \qquad j = R, U$$

Note that if $\phi < 0$ then there are negative externalities associated with population growth due to migration into a location. Note also that e reduces to unity when migration ceases. This reflects the idea that the externalities associated with city growth reflect transitions where population growth exceeds the ability of the location to absorb the new immigrants. In a stationary state, migration ends and the city augments its infrastructure to reflect its new size.

In the following we shall specialize the utility function to the CRRA form:

$$u(c) = \frac{c^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}},$$

where σ denotes the intertemporal elasticity of substitution.

The budget constraints facing individuals in the two periods of their lives are

$$\text{young: } \tau_t I_t^{ij} = b_{t+1}^i, \qquad i = R, U \tag{3.8}$$

$$\text{old: } c_{t+1}^{ijA} + p_{t+1} c_{t+1}^{ijN} + R_{t+1} b_{t+1}^i I_t^{ij} + \frac{T_{t+1}}{L_{t+1}} = w_{t+1}^{jA} l_{t+1}^{ijA} + \left(w_{t+1}^{jN} - \tau_{t+1}^j\right) l_{t+1}^{ijN} + \frac{\sum_{j=R,U}\left(\Pi_{t+1}^{jA} + \Pi_{t+1}^{jN}\right)}{L_{t+1}}, \quad i, j = R, U \tag{3.9}$$

where R_{t+1} denotes the gross interest factor on loans b_{t+1} contracted in period t. I_t^{ij} is an indicator function that takes a value of one if a young individual at time t in location i decides to migrate to location j, and equals 0 otherwise. l^{ij} denotes the labor supplied by an individual born in location i and working in location j. $L_{t+1} = L_{t+1}^R + L_{t+1}^U$ denotes the total population of old at time $t+1$. The last term on the right hand side of equation (3.9) reflects the fact that all firms are owned equally by the old who receive dividends from firms in proportion to their ownership. $\frac{T}{L}$ denotes the common per capita lump sum tax that is imposed by the government on all households.

The first-order-condition dictating the optimal consumption mix of the two goods is given by

$$p_t = \left(\frac{1-\theta}{\theta}\right)\left(\frac{c_t^{ijA} - \bar{a}}{c_t^{ijN} + \bar{n}}\right), \quad i, j = R, U \tag{3.10}$$

Combining equation (3.10) with the budget constraint (3.9) yields the optimal consumption plans of the old in location j at date t as:

$$c_t^{ijA} = \theta\left[\hat{y}_t^{ij} + \left(\frac{1-\theta}{\theta}\right)\bar{a} + p_t \bar{n}\right], \qquad j = R, U \tag{3.11}$$

$$p_t c_t^{ijN} = (1-\theta)\left[\hat{y}_t^{ij} - \bar{a} - \left(\frac{\theta}{1-\theta}\right) p_t \bar{n}\right], \qquad j = R, U \tag{3.12}$$

where $\hat{y}_t^{ij} = w_t^{jA} l_t^{ijA} + \left(w_t^{jN} - \tau_t^j\right) l_t^{ijN} - R_t b_t^i I_{t-1}^i - \frac{T_t}{L_t} + \frac{\sum_{j=R,U}\left(\Pi_t^{jA}+\Pi_t^{jN}\right)}{L_t}$ denotes the disposable income of a worker in location j at time t who was born in location i at date $t-1$.

The optimal labor supply decision of a worker in location $j = R, U$ at date t dictates that

$$w_t^{jA} = w_t^{jN} - \tau_t^j, \quad j = R, U \tag{3.13}$$

This condition reflects the fact that the worker can freely allocate their labor time to either the agricultural sector or to the non-agricultural sector in their location at cost τ^j per unit of labor supplied to the non-agricultural sector.

Before proceeding further, it is worth noting that since all individuals supply their one unit of labor time inelastically to the market, and since all individuals in a location i face the same sectoral wages in that location, w^{jA} and w^{jN}, the sectoral labor allocation by all individuals in the same location must be identical, i.e., $l_t^{ijk} = l_t^{jjk} = l_t^{jk}$ for all t and for all $i, j = R, U$ and $k = A, N$.

3.4.1 Location decision

The young at date t get to choose where they want to work next period. If they choose to change locations then they have to pay a fixed cost τ. The location decision of the young at date t is dictated by a comparison of lifetime utility at each location. To illustrate the mechanics of this decision recall that V_t^{ij} denotes the lifetime utility of a worker born at date t in location i and working in location j when old. The optimal consumption plans given in equations (3.11) and (3.12) above imply that

$$V_t^{ij} = u\left(\frac{\Gamma}{p_{t+1}^{1-\theta}}\left\{\hat{y}_{t+1}^{ij} - \bar{a} + p_{t+1}\bar{n}\right\}\right)\varepsilon_{t+1}^j, \quad i, j = R, U$$

where $\Gamma \equiv \theta^\theta (1-\theta)^{1-\theta}$. This expression shows that there are four types of workers at any date depending on where the worker was born and where she chose to locate as a worker. Using equation (3.13) and the fact that each worker has one unit of labor time when old, the disposable income of the four types of workers are

$$\hat{y}_{t+1}^{RR} = w_{t+1}^{RA} - \frac{T_{t+1}}{L_{t+1}} + \frac{\sum_{j=R,U}\left(\Pi_{t+1}^{jA} + \Pi_{t+1}^{jN}\right)}{L_{t+1}} \tag{3.14}$$

$$\hat{y}_{t+1}^{RU} = w_{t+1}^{UA} - R_{t+1}\tau_t - \frac{T_{t+1}}{L_{t+1}} + \frac{\sum_{j=R,U}\left(\Pi_{t+1}^{jA} + \Pi_{t+1}^{jN}\right)}{L_{t+1}} \tag{3.15}$$

$$\hat{y}_{t+1}^{UR} = w_{t+1}^{RA} - R_{t+1}\tau_t - \frac{T_{t+1}}{L_{t+1}} + \frac{\sum_{j=R,U}\left(\Pi_{t+1}^{jA} + \Pi_{t+1}^{jN}\right)}{L_{t+1}} \tag{3.16}$$

$$\hat{y}_{t+1}^{UU} = w_{t+1}^{UA} - \frac{T_{t+1}}{L_{t+1}} + \frac{\sum_{j=R,U}\left(\Pi_{t+1}^{jA} + \Pi_{t+1}^{jN}\right)}{L_{t+1}} \tag{3.17}$$

Since all young individuals can switch location, and there is perfect foresight, for individuals to be indifferent between changing locations or staying on where they were born, their lifetime welfare must be independent of their location choice when young. This implies that

$$V_t^{RR} = V_t^{RU}; \quad V_t^{UR} = V_t^{UU}$$

Given the positive cost of migration and no individual specific amenity effects, in this environment we will either have rural born individuals moving to the urban location or urban individuals moving to the rural location but not simultaneous movement in both directions. To see this note that the rural young will migrate to urban areas only if $V_t^{RU} \geq V_t^{RR}$ while the urban young workers will migrate to rural areas if $V_t^{UR} \geq V_t^{UU}$. For simultaneous migration in both directions we must then have

$$\frac{V_t^{RU}}{V_t^{RR}} \geq 1 \geq \frac{V_t^{UU}}{V_t^{UR}}$$

It is easy to check that with $\tau > 0$ this is generically contradictory. Hence, migration flows will occur in only one direction. Without loss of generality, in the remainder of the paper we shall restrict attention to parameter ranges such that $\frac{V_t^{RU}}{V_t^{RR}} \geq 1 \geq \frac{V_t^{UR}}{V_t^{UU}}$ which implies that only individuals born in rural areas would have an incentive to change locations.

A rural young would be indifferent between switching and not switching locations if and only if $V_t^{RR} = V_t^{RU}$. This gives the indifference condition

$$w_{t+1}^{UA} - R_{t+1}\tau_t - w_{t+1}^{RA} = \left[\left(\frac{\varepsilon_{t+1}^R}{\varepsilon_{t+1}^U} \right)^{\frac{\sigma}{\sigma-1}} - 1 \right] \left(\hat{y}_{t+1}^{RR} - \bar{a} + p_{t+1}\bar{n} \right). \tag{3.18}$$

This condition must be satisfied at all dates in our economy. In other words, a rural young would be indifferent between staying in the rural location or moving to the urban location if the wage increase that the location switch will generate for her tomorrow net of the moving cost she incurs is exactly equal to the foregone relative utility from staying on in the rural location. Note that when the amenities of the two locations are identical so that $\varepsilon_{t+1}^R = \varepsilon_{t+1}^U$, the indifference condition reduces to $w_{t+1}^{UA} - R_{t+1}\tau_t = w_{t+1}^{RA}$.[16,17]

3.5 Government

A key feature of the model is that the young have to decide on their location decision when they have no source of income. Consequently, this has to be financed through borrowing. We assume that there is a government agency that imposes a lump sum tax T on households and uses these proceeds along with the repayments of past loans by current workers to finance new loans to the young in any

[16] We assume that the initial old generation at date $t = 0$ can freely choose their location so that $w_0^{UA} - w_0^{RA} = \left[\left(\frac{\varepsilon_0^R}{\varepsilon_0^U} \right)^{\frac{\sigma}{\sigma-1}} - 1 \right] \left(\hat{y}_0^{RR} - \bar{a} + p_0\bar{n} \right)$.

[17] Note that from equation (3.18), the urban-rural wage gap would be rising (falling) with $\frac{\varepsilon^R}{\varepsilon^U}$ as $\sigma > (<)1$. Consequently, the urban-rural wage gap would widen (decline) with migration into urban areas if migration worsens (raises) urban amenities.

period. The budget constraint of the government is

$$T_t + \mu_{t-1} L_{t-1}^R R_t b_t = \mu_t L_t^R b_{t+1}$$

where μ_t denotes the measure of rural young that choose to change location at date t. From equation (3.8) it is clear that $b_t = \tau_t$ for all t since borrowing is needed only to finance the location switching cost. Hence, the government's budget constraint can be written as

$$T_t + \mu_{t-1} L_{t-1}^R R_t \tau_{t-1} = \mu_t L_t^R \tau_t \tag{3.19}$$

The government can either choose the interest rate R_t or adjust the lump sum tax T_t to ensure that equation (3.19) holds at every t for all values of the other variables. We shall assume that the credit agency lends to the young at a constant interest factor so that $R_t = R$ for all t.[18] In this case T_t becomes endogenous and is given by

$$T_t = \mu_t L_t^R \tau_t - \mu_{t-1} L_{t-1}^R R \tau_{t-1}.$$

3.6 Aggregation

To complete the description of this economy, we now aggregate the individual variables to represent aggregate variables. First, the population dynamics of the two locations and the economy as a whole are given by

$$L_t^R = \left(1 - \mu_{t-1}\right) L_{t-1}^R \tag{3.20}$$

$$L_t^U = L_{t-1}^U + \mu_{t-1} L_{t-1}^R \tag{3.21}$$

$$L_t = L_t^R + L_t^U \tag{3.22}$$

The total sectoral allocation of labor in each location is given by

$$L_t^{Uk} = l_t^{UUk} L_{t-1}^U + l_t^{RUk} \mu_{t-1} L_{t-1}^R, \quad k = A, N$$

$$L_t^{Rk} = l_t^{Rk} \left(1 - \mu_{t-1}\right) L_{t-1}^R, \quad k = A, N$$

Next, we use the individual consumption plans to derive aggregate values of consumption of the two goods. At every date there are three types of workers in this economy – those that were born and work in rural areas; those that were born and work in urban areas; and those that were born in rural areas but changed locations to work in urban areas. Hence,

$$C_t^{Uk} = c_t^{UUk} L_{t-1}^U + c_t^{RUk} \mu_{t-1} L_{t-1}^R, \quad k = A, N$$

[18] Alternatively, the government could finance the switching cost by setting $T_t = 0$ for all t but for the funding agency to adjust the interest rate every period to ensure that $\mu_{t-1} L_{t-1}^R R_t \tau_{t-1} = \mu_t L_t^R \tau_t$. This amounts to the migrant workers being charged an interest rate that is just sufficient to finance location switches by young rural individuals at every date. In this case the interest rate would become endogenous and be given by $R_t = \frac{\mu_t L_t^R \tau_t}{\mu_{t-1} L_{t-1}^R \tau_{t-1}}$. In this scenario, the initial period switches at $t = 0$ would be financed through a one-time lump sum tax $T_0 = \mu_0 L_0^R \tau_0$.

$$C_t^{Rk} = c_t^{RRk}\left(1-\mu_{t-1}\right)L_{t-1}^R, \quad k = A, N$$

give the total consumption of each good in the two locations. Clearly, aggregate consumption of the two goods are $C_t^k = C_t^{Uk} + C_t^{Rk}$ where $k = A, N$.

Using the optimal consumption plans given by equations (3.11) and (3.12), and combining them with the firms' and the funding agencies budget constraints, we can write the aggregate consumption demand of the two goods as

$$C_t^A = \theta\left[Y_t^A + p_t Y_t^N - \tau_t^R L_t^{RN} - \tau_t^U L_t^{UN} - \tau_t\mu_t L_t^R\right] + \left[(1-\theta)\bar{a} + \theta p_t \bar{n}\right]L_t \tag{3.23}$$

$$p_t C_t^N = (1-\theta)\left[Y_t^A + p_t Y_t^N - \tau_t^R L_t^{RN} - \tau_t^U L_t^{UN} - \tau_t\mu_t L_t^R\right] - \left[(1-\theta)\bar{a} + \theta p_t \bar{n}\right]L_t \tag{3.24}$$

3.7 Equilibrium

To describe the equilibrium for this economy we first note that at every date all equilibrium allocations must be consistent with market clearing in each sector, i.e.,

$$C_t^A + \tau_t^R L_t^{RN} + \tau_t^U L_t^{UN} + \tau_t\mu_t L_t^R = Y_t^A \tag{3.25}$$

$$C_t^N = Y_t^N \tag{3.26}$$

Define the price and quantity vectors, Ψ and Ω respectively, as

$$\begin{aligned}\Psi_t &= \left\{p_t, w_t^{UA}, w_t^{UN}, w_t^{RA}, w_t^{RN}\right\}\\ \Omega_t &= \left\{c_t^{UUA}, c_t^{UUN}, c_t^{RUA}, c_t^{RUN}, c_t^{RRA}, c_t^{RRN}, l_t^{UUA}, l_t^{UUN}, l_t^{RUA}, l_t^{RUN}, l_t^{RRA}, l_t^{RRN}, \mu_t\right\}\end{aligned}$$

Definition: *The perfect foresight competitive equilibrium for this economy is a time path of the vectors (Ψ_t, Ω_t) such that all young and old individuals, and firms satisfy their optimality conditions, budget constraints are satisfied and all markets clear at all dates for a given path of the productivity vector $\left\{A_t^R, A_t^U, N_t^R, N_t^U\right\}$.*

3.7.1 Characterizing the equilibrium

To describe the equilibrium of this model in greater detail and characterize its properties, substitute the aggregate solution for C^A into the market clearing conditions given by equation (3.25) to get

$$\begin{aligned}&\theta\left[Y_t^A + p_t Y_t^N - \tau_t^R L_t^{RN} - \tau_t^U L_t^{UN} - \tau_t\mu_t L_t^R\right] + \left[(1-\theta)\bar{a} + \theta p_t \bar{n}\right]L_t\\ =\ & Y_t^A - \tau_t^R L_t^{RN} - \tau_t^U L_t^{UN} - \tau_t\mu_t L_t^R\end{aligned}$$

This expression can be rewritten as

$$p_t = \left(\frac{1-\theta}{\theta}\right)\left[\frac{Y_t^A - \bar{a}L_t - \tau_t^R L_t^{RN} - \tau_t^U L_t^{UN} - \tau_t\mu_t L_t^R}{Y_t^N + \bar{n}L_t}\right] \tag{3.27}$$

In addition, the optimality condition for sectoral labor allocations given by equation (3.13) implies that $w_t^{RA} + \tau_t^R = w_t^{RN}$ and $w_t^{UA} + \tau_t^U = w_t^{UN}$. These imply two independent conditions that must hold at all times:

$$p_t = \frac{\alpha^R A_t^R \left(L_t^{RA}\right)^{\alpha^R - 1} + \tau_t^R}{\beta^R N_t^R \left(L_t^{RN}\right)^{\beta^R - 1}} \tag{3.28}$$

$$\frac{\alpha^R A_t^R \left(L_t^{RA}\right)^{\alpha^R - 1} + \tau_t^R}{\beta^R N_t^R \left(L_t^{RN}\right)^{\beta^R - 1}} = \frac{\alpha^U A_t^U \left(L_t^{UA}\right)^{\alpha^U - 1} + \tau_t^U}{\beta^U N_t^U \left(L_t^{UN}\right)^{\beta^U - 1}} \tag{3.29}$$

The indifference condition for the location decision dictates that

$$w_t^{UA} - R\tau_{t-1} - w_t^{RA} = \left[\left(\frac{\varepsilon_t^R}{\varepsilon_t^U}\right)^{\frac{\sigma}{\sigma-1}} - 1\right]\left(\hat{y}_t^{RR} - \bar{a} + p_t \bar{n}\right)$$

which, using the firms' optimal labor demand conditions, gives

$$\alpha^U A_t^U \left(L_t^{UA}\right)^{\alpha^U - 1} - R\tau_{t-1} - \alpha^R A_t^R \left(L_t^{RA}\right)^{\alpha^R - 1} = \left[\left(\frac{\varepsilon_t^R}{\varepsilon_t^U}\right)^{\frac{\sigma}{\sigma-1}} - 1\right]\left(\hat{y}_t^{RR} - \bar{a} + p_t \bar{n}\right) \tag{3.30}$$

Since the labor adding up constraint in each location at any date t implies that

$$L_t^j = L_t^{jA} + L_t^{jN}, \quad j = R, U$$

it is easy to verify that equations (3.27), (3.28), (3.29) and (3.30) define a system of four equations in four unknowns – L_t^{RA}, L_t^{UA}, p_t and μ_t – as functions of the state vector $\mathbf{S}_t = \left\{A_t^j, N_t^j, L_t^j, \tau_t^j, \tau_t\right\}$. All the other variables of the model can then be determined recursively once the solution for these four variables are obtained from this system. Note that the choice of μ_t induces a new distribution of rural and urban workers at time $t+1$ given by L_{t+1}^R and L_{t+1}^U.

4 A Special Case

In order to build intuition regarding the model, we now specialize our environment to facilitate analytical progress. Specifically, we make five assumptions:

Assumption 1. $\alpha^R = \alpha^U = \beta^R = \beta^U = \beta$.
Assumption 2. $\tau_t^R = \tau_t^U = 0$.
Assumption 3. $\tau_t = 0$.
Assumption 4. $\frac{A_t^R}{A_t^U} \geq \frac{N_t^R}{N_t^U}$.
Assumption 5. $\varepsilon_t^U = \varepsilon_t^R$ for all t.

Assumption 1 implies that production technologies differ across locations and sectors solely due to differences in total factor productivities and nothing else. Assumption 2 sets the training costs of switching to the non-agricultural sector to zero. Assumption 3 makes mobility across locations costless. Assumptions 2 and 3 jointly convert our environment into a model with no frictions in labor allocations, either across sectors or across locations. Assumption 4 implies that rural locations are relatively more productive in producing the agricultural good while urban locations are relatively more productive in producing the non-agricultural good. Assumption 5 says that there are no amenity differences between urban and rural locations. Recalling equation (3.7), this amounts to assuming that $\phi = 0$ and $\bar{\varepsilon}^j = \bar{\varepsilon}$ for all j. This assumption implies that the migration indifference condition for the rural young reduces to $w_t^{UA} - R\tau_{t-1} = w_t^{RA}$. This greatly simplifies the analytical illustration of the effects of productivity shocks in this economy.

In the following it shall also be useful to follow the notation:

$$k^A = \frac{L^{UA}}{L^{RA}}, \quad k^N = \frac{L^{UN}}{L^{RN}}, \quad k = \frac{L^U}{L^R}, \quad s^A = \frac{L^{RA}}{L^R} \tag{4.31}$$

Noting that $\frac{L^{UA}}{L^{RA}}\frac{L^{RA}}{L^R} + \frac{L^{UN}}{L^{RN}}\frac{L^{RN}}{L^R} = \frac{L^U}{L^R}$, it is easy to verify that one can use the definitions in (4.31) to get

$$s^A = \frac{k - k^N}{k^A - k^N} \tag{4.32}$$

Of particular interest to us is the variable $k = \frac{L^U}{L^R}$. It represents the degree of *urbanization* of the economy since it gives the distribution of a given workforce between urban and rural locations.

Under our notational convention in (4.31) and Assumptions 1 and 2, the optimality condition given by equation (3.29) reduces to

$$k_t^N = \gamma_t k_t^A, \quad \gamma_t \equiv \left(\frac{A_t^R/A_t^U}{N_t^R/N_t^U}\right)^{\frac{1}{1-\beta}} \tag{4.33}$$

Moreover, under Assumption 4 above, $\gamma_t \geq 1$ for all t. Hence, the non-agricultural sector employs relatively more urban labor while the agricultural sector is more intensive in rural labor.

Next, we can rewrite the indifference condition for switching locations, equation (3.30), as

$$k_t^A = \left[\frac{A_t^U}{A_t^R} - \frac{R_t\tau_{t-1}}{\beta A_t^R}\left\{\frac{\left(\gamma_t k_t^A - k_t\right)L_t}{\left(\gamma_t - 1\right)\left(1 + k_t\right)}\right\}^{1-\beta}\right]^{\frac{1}{1-\beta}} \tag{4.34}$$

This equation, updated one period, gives the solution for k_{t+1}^A as a function of L_{t+1}, k_{t+1} and γ_{t+1}, all of which are part of the state space at date $t+1$. Under Assumptions 1 and 2, the expression for k_{t+1}^A reduces to

$$k_t^A = \left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}}$$

Since $k^N = \gamma k^A$ and $s^A = \frac{k-k^N}{k^A-k^N}$, the expression for k^A above also implies that $k_t^N = \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}$ and $s_t^A = \frac{k_t - \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}}{\left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}} - \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}}$. Clearly, given an initial urbanization level k_t and the sectoral productivities A_t^j and N_t^j , the allocation of rural and urban labor to the two sectors is fully determined.

While aggregate population and sectoral productivities both follow exogenous processes, the urbanization of the economy given by the urban to rural labor ratio $k_{t+1} = \frac{L_{t+1}^U}{L_{t+1}^R}$ evolves endogenously over time. Using equations (3.20) and (3.21), the evolution equation for k can be written as

$$k_{t+1} = \frac{k_t + \mu_t}{1 - \mu_t} \tag{4.35}$$

which can be rewritten as

$$\mu_t = \frac{k_{t+1} - k_t}{1 + k_{t+1}} \tag{4.36}$$

Hence, at every date t, once the productivity realizations for the period are known, all labor and sectoral allocations are known. The locational allocations of labor for next period in turn are fully determined once next period's productivity realizations (or, more generally, their expectations) are formed.

Substituting all of these relations in equations (3.27) and (3.28), equating the two, and rearranging the result gives:

$$\left(\frac{k_t - \gamma_t k_t^A}{k_t^A - k_t}\right)^{\beta-1} = \left(\frac{1-\theta}{\theta}\right)\left[\frac{\left(\frac{k_t - \gamma_t k_t^A}{(1-\gamma_t)k_t^A}\right)^{\beta}\left(1 + k_t^A\right) - \frac{\bar{a}}{A_t^R}\left(1 + k_t\right)^{\beta} L_t^{1-\beta}}{\left(\frac{k_t^A - k_t}{(1-\gamma_t)k_t^A}\right)^{\beta}\left(1 + \gamma_t k_t^A\right) + \frac{\bar{n}}{N_t^R}\left(1 + k_t\right)^{\beta} L_t^{1-\beta}}\right] \tag{4.37}$$

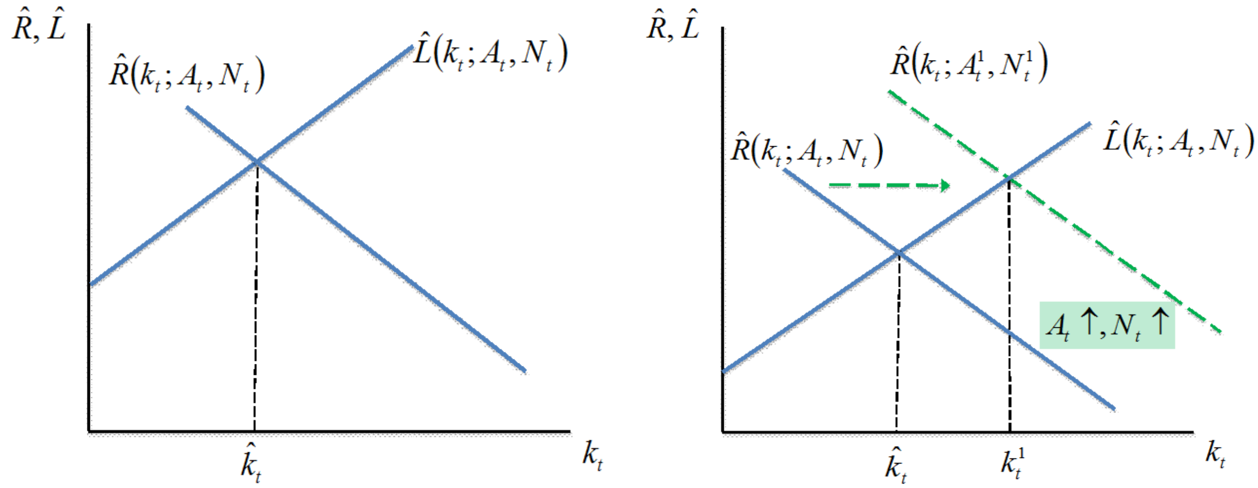
Since $k_t^A = \left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}}$ is solely a function of agricultural productivities in urban and rural locations, equation (4.37) determines the solution for k_t as a function of sectoral productivities and aggregate labor supply at each date t. Consequently, along any perfect foresight equilibrium path, at date t one can compute the equilibrium degree of urbanization k_{t+1} from equation (4.37) by updating it one period. This solution then implies that μ_t, the equilibrium measure of young individuals in rural locations who switch locations at date t, can be determined from equation (4.36).[19]

To characterize the equilibrium and examine the effects of various shocks on the economy, it is useful to represent equation (4.37) graphically. Let $\hat{L}_t$ and $\hat{R}_t$ be the left and right hand sides of equation (4.37). Panel (a) of Figure 11 shows that $\hat{L}_t$ is rising in k_t while $\hat{R}_t$ is declining in k_t. The equilibrium degree of urbanization at each date t is denoted by $\hat{k}_t$. For unchanging productivities A^j and N^j, the equilibrium k_t will also be constant over time, i.e., the solution will describe the steady state level of urbanization.

In terms of adjustment dynamics, along paths with a constant population and stationary productivities, the transition to steady state occurs with a maximum lag of one period. Given any initial k_0, the solution for k_1 from equation (4.37) determines the equilibrium μ_0. From $t = 1$ onwards, there are no further changes in the population distribution between rural and urban locations and the economy remains completely stationary.

[19] Note that our assumption of zero population growth implies that L_t is constant and independent of time.

Figure 11: Equilibrium k and productivity shocks



(a) Equilibrium level of urbanization (b) Rise in aggregate productivity

4.1 Productivity Shocks

There are four different productivity parameters in the model: A^R, A^U, N^R, N^U. This allows us to examine the effects of both aggregate productivity shocks as well as sectoral productivity shocks. In addition, the special case of the model also allows us to analyze the effects of productivity shocks when labor cannot migrate from rural to urban locations. We examine all of these in this subsection.

4.1.1 Aggregate productivity growth

We first consider aggregate productivity shocks that raise the productivity levels of A^R, A^U, N^R, N^U equiproportionately at each date. More specifically, suppose the productivity processes are given by

$$A_{t+1}^j = (1+g)\, A_t^j, \quad j = R, U \tag{4.38}$$
$$N_{t+1}^j = (1+g)\, N_t^j, \quad j = R, U \tag{4.39}$$

where $g > 0$ gives the rate of balanced aggregate productivity growth. Hence, $\frac{A_t^U}{A_t^R}, \frac{N_t^U}{N_t^R}, \frac{N_t^U}{A_t^U}$ and $\frac{N_t^R}{N_t^U}$ all remain unchanged even though the levels of all the productivity parameters rise permanently at each t. In terms of equation (4.37), only the right hand side is affected as $\frac{\bar{a}}{A_t^R}(1+k_t)^\beta L_t^{1-\beta}$ and $\frac{\bar{n}}{N_t^R}(1+k_t)^\beta L_t^{1-\beta}$ both decline along such productivity paths. As a result, for every level of k_t the right hand side rises. In terms of Figure 11, panel (b) of the figure shows that at each date $\hat{R}$ shifts up and to the right in response to this aggregate productivity. Hence, the equilibrium $\hat{k}_t$ rises. This implies that along paths with aggregate productivity growth urbanization rises secularly over time.

The allocation of labor in each location to the two sectors is given by $\frac{L_t^{RA}}{L_t^R} = s_t^A$ and $\frac{L_t^{UA}}{L_t^U} = \frac{k_t^A s_t^A}{k_t}$. Along paths with aggregate productivity growth, $k_t^A = \left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}}$ remains unchanged while k_t rises.

Moreover, along paths with rising k_t, $s_t^A = \frac{k_t - \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}}{\left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}} - \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}}$ must decline since $\left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}} < \left(\frac{N_t^U}{N_t^R}\right)^{\frac{1}{1-\beta}}$. Hence, both $\frac{L_t^{RA}}{L_t^R}$ and $\frac{L_t^{UA}}{L_t^U}$ decline along paths with rising aggregate productivity. This implies that the employment share of agriculture in both locations falls while that of non-agriculture rises as the economy grows.

The overall share of agricultural employment in this economy is given by $\frac{L_t^A}{L_t} = \frac{L_t^{UA}}{L_t^U}\frac{L_t^U}{L_t} + \frac{L_t^{RA}}{L_t^R}\frac{L_t^R}{L_t}$ which can be rewritten as

$$\frac{L_t^A}{L_t} = \frac{s_t^A\left(1 + k_t^A\right)}{1 + k_t}$$

Since k^A is constant along paths with aggregate productivity growth while s^A falls and k rises, it is clear that $\frac{L_t^A}{L_t}$ must fall. Hence, the economy undergoes a structural transformation along paths with aggregate growth.

To complete a description of the economy along paths with aggregate productivity growth we need to describe the paths of goods and factor prices. Given that there are no costs of switching locations or sectors it is easy to see that factor prices must be equalized across sectors and locations in this special case, i.e.,

$$w_t^{RA} = w_t^{UA};\ w_t^{RA} = w_t^{RN};\ w_t^{UA} = w_t^{UN} \qquad \text{for all } t$$

The relative price of the non-agricultural good is given by $p_t = \frac{A_t^R}{N_t^R}\left(\frac{s_t^A}{1-s_t^A}\right)^{\beta-1}$. As we noted above, $\frac{A_t^R}{N_t^R}$ remains unchanged along paths with aggregate productivity increases while s_t^A declines. Hence, along paths with rising aggregate productivity the relative price of non-agriculture, p_t, must rise, i.e., the agricultural terms of trade worsens.

In the limit as $t \to \infty$, the non-homothetic components in the numerator and denominator of the right hand side of equation (4.37) vanish and the economy settles into balanced growth with a limiting stationary degree of urbanization given by

$$\hat{k} = \frac{\left[\hat{\gamma}\left(1 + \hat{k}^A\right) - \theta\left(\hat{\gamma} - 1\right)\right]\hat{k}^A}{1 + \left\{1 + \theta\left(\hat{\gamma} - 1\right)\right\}\hat{k}^A}$$

where $\hat{\gamma} = \left(\frac{A_0^R/A_0^U}{N_0^R/N_0^U}\right)^{\frac{1}{1-\beta}}$ and $\hat{k}^A = \left(\frac{A_0^U}{A_0^R}\right)^{\frac{1}{1-\beta}}$. It is easy to check that $\hat{k} > 0$. Furthermore, the associated limiting s_t^A is given by

$$\hat{s}^A = \frac{\hat{k} - \left(\frac{N_0^U}{N_0^R}\right)^{\frac{1}{1-\beta}}}{\left(\frac{A_0^U}{A_0^R}\right)^{\frac{1}{1-\beta}} - \left(\frac{N_0^U}{N_0^R}\right)^{\frac{1}{1-\beta}}}$$

We collect these results in the following Proposition:

Proposition 1 *Under Assumptions 1-5 and aggregate productivity growth given by equations (4.38)-*

(4.39), there is a secular decline in the agricultural employment share of overall labor as well as rural labor and urban labor individually. This structural transformation is accompanied by rising urbanization and a secular fall in the relative price of the agricultural good.

Intuitively, this is the standard structural transformation mechanism in models with non-homothetic preferences. The aggregate productivity increase raises the demand for non-agricultural goods more than the demand for the agricultural good. This relative demand shock raises the relative price of the non-agricultural good which, in turn, causes a reallocation of workers from agriculture to non-agriculture in both locations. The additional aspect here is that the higher relative price of non-agricultural goods raises the wage in the non-agricultural sector by more in urban locations since they are more productive in producing the non-agricultural good. This results in rising urbanization as young rural individuals migrate to urban locations in order to arbitrage the wage differential.

4.1.2 Sector-biased productivity change

We now examine the impact of productivity changes that are biased towards the non-agricultural sector. In particular, suppose the economy is initially in steady state with constant productivities in all sectors given by $A_0^R, A_0^U, N_0^R, N_0^U$. Denote this steady state as date $t = 0$. Now suppose that at $t = 0$ news arrives that the productivity process from $t = 1$ will be

$$A_t^j = (1 + \varepsilon g)\, A_0^j \text{ for all } t \geq 1, \;\; j = R, U \tag{4.40}$$

$$N_t^j = (1 + g)\, N_0^j, \quad j = R, U \tag{4.41}$$

where $\varepsilon < 1$ and $g > 0$. The shock permanently raises $\frac{N_t^j}{A_t^j}$ from $t \geq 1$ for $j = R, U$. Hence, this is a non–agriculture biased productivity change. Since $\frac{N_t^U}{N_t^R} = \frac{N_0^U}{N_0^R}$ and $\frac{A_t^U}{A_t^R} = \frac{A_0^U}{A_0^R}$, it directly follows that both $k_t^A = \left(\frac{A_t^U}{A_t^R}\right)^{\frac{1}{1-\beta}}$ and $\gamma_t = \left(\frac{A_t^R/A_t^U}{N_t^R/N_t^U}\right)^{\frac{1}{1-\beta}}$ remain unchanged. It is straightforward to verify from equation (4.37) that the degree of urbanization in the new steady state must be greater than the level of urbanization in the initial steady state, $k_1 > k_0$. This, in turn, implies that s^A, $\frac{L^{RA}}{L^R}$, $\frac{L^{UA}}{L^U}$ and $\frac{L^A}{L}$ must all decline permanently in response to the shock.

The response of p, the relative price of the non-agricultural good, is however ambiguous since there are two offsetting effects. On the one hand, the productivity process implies that $\frac{A^R}{N^R}$ falls. On the other hand, s^A declines as well. Consequently, the behavior of $p_t = \frac{A_t^R}{N_t^R}\left(\frac{s_t^A}{1-s_t^A}\right)^{\beta-1}$ is ambiguous and depends on the relative strengths of these two opposing effects. As before, there are no sectoral or locational wage differences in this special case since there are no costs of switching. We collect these results in the following Proposition:

Proposition 2 *Under Assumptions 1-5 and N-sector-biased productivity growth given by equations (4.40)-(4.41), there is a decline in the agricultural employment share of overall labor as well as of rural labor and urban labor individually. This structural transformation is accompanied by an increase in the degree of urbanization. The movement in the relative price of the agricultural good however is ambiguous.*

Qualitatively, the predictions for structural transformation are identical in the two cases. The main difference in outcomes between the case of aggregate productivity growth and sector-biased productivity growth then is the impact on the relative goods price. The faster growth in non-agricultural productivity causes an increase in the relative supply of the non-agricultural good. This supply effect provides a counter-weight to the increase in the relative demand for the non-agricultural good. This makes the effect on relative price ambiguous.[20]

4.1.3 No Migration

The analysis above focused on the extreme case of frictionless labor markets across sectors and locations. We now consider the other extreme case in which frictions associated with location switching are so large that there is no migration across locations, i.e., L^R and L^U are constant over time. To ease the analytics, assume that the sectoral productivities are constant over time, i.e., $A_t^j = A^j$ and $N_t^j = N^j$, $j = R, U$. In this special case, the location migration indifference condition (equation (3.30)) does not apply and consequently, neither does equation (4.34). Equating equations (3.27) and (3.28), setting $\tau^R = \tau^U = 0$ and $\alpha = \beta$, and rearranging the resulting expression gives

$$\left(\frac{L_t^{RA}}{L^R - L_t^{RA}}\right)^{\beta-1} = \left(\frac{1-\theta}{\theta}\right)\left[\frac{\left(L_t^{RA}\right)^{\beta} + \frac{A_t^U}{A_t^R}\left(L^U - L_t^{UN}\right)^{\beta} - \frac{\bar{a}L}{A_t^R}}{\left(L^R - L_t^{RA}\right)^{\beta} + \frac{N_t^U}{N_t^R}\left(L_t^{UN}\right)^{\beta} + \frac{\bar{n}L}{N_t^R}}\right] \tag{4.42}$$

Moreover, we can rewrite the relationship $k_t^N = \gamma_t k^A$ as $\frac{L_t^{UN}}{L_t^{RN}} = \gamma_t \frac{L_t^{UA}}{L_t^{RA}}$ where $\gamma_t \equiv \left(\frac{A_t^R/A_t^U}{N_t^R/N_t^U}\right)^{\frac{1}{1-\beta}} > 1$ by Assumption 4 above. This can be rewritten as

$$\frac{L_t^{UN}}{L^U - L_t^{UN}} = \gamma_t \left(\frac{L^R - L_t^{RA}}{L_t^{RA}}\right)$$

Clearly the left hand side is rising in L_t^{UN} while the right hand side is declining in L_t^{RA}. Hence, L_t^{UN} is a decreasing function of L_t^{RA}.

$$L_t^{RN} = \varrho\left(L_t^{RA}, \gamma_t\right), \quad \varrho_{L^{RA}} < 0$$

Hence, equation (4.42) is only a function of L_t^{RA}. It is easy to check that the left hand side of equation (4.42) is decreasing in L_t^{RA} while the right hand side is rising in L_t^{RA}. Consequently, equation (4.42)

[20] A different but related experiment would be an unanticipated, permanent increase in sectoral or aggregate productivity starting from a steady state. Thus, suppose all sectoral productivities are constant over time and the economy is in steady state. Now, suppose A^j rises permanently by a factor γ^A and N^j rises by a factor γ^N for $j = R, U$. In this case, the location indifference condition at the initial date will clearly not hold since workers cannot move within that period. Hence, the initial distribution of L would be exogenously given and rural and urban wages would not be equalized at the initial date. It can be shown that such an unanticipated increase in aggregate productivity would induce a structural transformation with rising employment shares of the non-agricultural sector in both locations. However, the urban-rural wage gap would widen and the price of the non-agricultural good would rise in the period of the shock. Analogously, a permanent unanticipated increase in the productivity of sector-N relative to sector-A (an N-sector biased technological improvement), would have similar effects on the structural transformation but have ambiguous effects on the relative price of good N and on the wage gap in the period of the shock. The adjustments in the next period to both shocks would be as described in the propositions above.

yields a unique solution for L_t^{RA} at each $t \geq 0$. The equilibrium values all other variables can then be derived recursively.

Having characterized the equilibrium when there is no migration across locations, we now examine the impact of an aggregate productivity increase in this economy. Specifically, assume that productivity in both sectors in both locations rises by the same proportion:

$$A_t^j = (1+g)^t A_0^j, \quad j = R, U \tag{4.43}$$

$$N_t^j = (1+g)^t N_0^j, \quad j = R, U \tag{4.44}$$

where A_0^j and N_0^j denote the initial productivity levels in the two sectors for $j = R, U$.

The structural transformation that is induced by productivity increases is easy to see directly from equation (4.42). An increase in A_t^R and N_t^R unambiguously increase the right hand side of (4.42). Since the left hand side is declining in L_t^{RA} while the right hand side of (4.42) is rising in L_t^{RA}, the equation can hold with equality if and only if L_t^{RA} falls. Since L_t^{UN} is declining in L_t^{RA}, L_t^{UA} must fall as well. Hence, agricultural employment declines in both locations. The optimal sectoral labor allocation in rural areas gives $p_t = \frac{A_t^R}{N_t^R}\left(\frac{L_t^{RA}}{L_t^{RN}}\right)^{\beta-1} = \frac{A_0^R}{N_0^R}\left(\frac{L_t^{RA}}{L_t^{RN}}\right)^{\beta-1}$. Since L_t^{RA} falls, p_t must rise, i.e., the relative price of the agricultural good *falls*.

Since there are no inter-sectoral wage gaps within each location under Assumption 2, $\tau^R = \tau^U = 0$, the urban-rural wage gap is given by $\frac{w^{UA}}{w^{RA}}$. From the firm optimality conditions we have $\frac{w_t^{UA}}{w_t^{RA}} = \frac{A_t^U}{A_t^R}\left(\frac{L_t^{UA}}{L_t^{RA}}\right)^{\beta-1} = \frac{A_0^U}{A_0^R}\left(\frac{L_t^{UA}}{L_t^{RA}}\right)^{\beta-1}$. Using the definition $k^A \equiv \frac{L^{UA}}{L^{RA}}$, we can rewrite the wage gap as

$$\frac{w_t^{UA}}{w_t^{RA}} = \frac{A_0^U}{A_0^R}\left(k_t^A\right)^{\beta-1}$$

The effect of the productivity increase on the urban-rural wage gap depends on the response of k^A. If k^A declines then the wage gap widens. From equation (4.32) above $s_t^A = \frac{k-k_t^N}{k_t^A-k_t^N} = \frac{\gamma-\frac{k}{k_t^A}}{\gamma-1}$ where $\gamma \equiv \left(\frac{A_0^R/A_0^U}{N_0^R/N_0^U}\right)^{\frac{1}{1-\beta}}$ Clearly, s_t^A is rising in k_t^A. We have seen above that s_t^A declines as productivity rises. Hence, k_t^A must decline as productivity parameters A^j and N^j rise, $j = R, U$. Hence, the urban-rural wage gap widens with rising productivity.

In the limit as $t \to \infty$, the non-homothetic components in the numerator and denominator of the right hand side of equation (4.42) vanish and the economy settles into balanced growth with a stationary sectoral labor allocation in each location.

We collect these results in the following Proposition:

Proposition 3 *Under Assumptions 1, 2, 4 and 5, and aggregate productivity growth given by equations (4.43) and (4.44), the agricultural employment share of both rural labor and urban labor declines. This structural transformation is accompanied by a widening of the urban-rural wage gap and a fall in the relative price of the agricultural good.*

The propositions above highlight the key forces at play in the model. They show that productivity changes in the model generate two competing effects on prices and allocations. First, from Proposition 3 we see that an aggregate productivity growth triggers an increase in relative demand for non-agricultural goods, and leads to a rise in the non-agricultural relative price. This raises the wages of non-agricultural workers relative to the wages of agricultural workers. The consequence of this is worker reallocation from agricultural to non-agricultural employment. Since urban locations are predominantly non-agricultural, the urban-rural wage gap widens. This is the standard demand-driven explanation of structural transformation. We refer to this as the "demand effect".

The second effect is highlighted by Propositions 1 and 2 and arises as a consequence of the first effect. Specifically, widening urban-rural wage gaps also trigger migration from rural to urban areas. Net migration into urban areas increases labor supply in those areas. This in turn leads to a higher production of non-agricultural goods, moving the sectoral terms of trade against them. This brings wages of urban workers closer to the wages of rural workers, i.e. the urban-rural wage gap declines. We refer to this effect as the "urbanization effect". Without any labor market frictions, the urban-rural wage gap completely disappears.

5 Quantitative Results

We now quantitatively assess the ability of the full model to explain the observed rural-urban wage dynamics along with the aggregate macroeconomic facts. To do so we calibrate the model separately for India and China to match their conditions at the initial dates of our data sample. In particular, for China we use year 1988 as representing its initial steady state, while for India we use year 1983. We then conduct the following experiment. We first measure the actual changes in sectoral labor productivities in China during 1988-2008, and in India during 1983-2010 period. Keeping all the calibrated parameters unchanged, we then feed these measured changes in sectoral productivities into the model and examine their effects on goods prices, factor prices, factor allocations and migration.

5.1 Calibration for the 1980s

We calibrate the model parameters to match the key moments of wages and employment in the data. More precisely, we choose eleven parameters that minimize the distance between eleven moments in the data in the 1980s and in the model. Our first set of calibration targets are the urban and rural shares of the employment which gives us one independent data moment per country. For India in 1983, we measure these using data from the Census of India and the NSS. These calculations give us the urban employment share at 22 percent of total in 1983.[21] In China the urban employment share was 26 percent in 1988.

Second, we match the sectoral distribution of the labor force in rural and urban areas summarized in Table 1. This gives us two independent moments to target. Third, we target the four conditional wage gaps also presented in Table 1: the two "within"sector wage gaps and the two "between" sector

[21] The Census of India is conducted every 10 years on the first year of each decade. Thus, in 1981 the total population of India was 683.3 million people, of which 525.6 million lived in rural areas and 157.7 million lived in urban areas. To obtain labor force numbers we multiply these population figures by the share of working age population in 1983 from the NSS equal to 0.54 in rural areas and 0.59 in urban areas; by the labor force participation rate in 1983 from the NSS equal to 0.66 in rural areas and 0.59 in urban areas; and by the share of employed in the labor force equal to 0.94 in urban areas and 0.96 in rural areas.

gaps. Our eighth data target is the output share of agriculture in total GDP. In India in 1983 this was 36 percent, while it was 17 percent in China in 1988.

Our last three data targets are moments that characterize consumption expenditures in the two countries: the share of agriculture in total household consumption; the home production share of non-agricultural goods and services; and the minimum consumption level of agricultural goods. In linking the model to the data above, we follow the value-added approach to interpreting a sector.[22] To keep the model internally consistent we define the arguments in the utility function in value added terms as well. We compute agricultural consumption in value added terms as the agricultural value added, and non-agricultural value-added consumption as non-agricultural value added minus investment.[23] This gives us the share of agricultural value added in total consumption equal to 47 percent in India and 33 percent in China. We target the home production share in the consumption of non-agricultural goods and services at 30 percent in both countries. This number is implied by the time allocation statistics in the US over our sample period, where US households spent on average 12 hours per week in home production and 40 hours per week in market employment. These numbers are also similar to those reported in China since the mid-2000s.[24]

We pin down the minimum consumption level of agricultural goods by following Anand and Prasad (2010) who estimated minimum consumption requirement value to be 50 percent of food consumption for a sample of six emerging economies, including India. We adjust this number to account for potential differences in minimum food consumption requirements in rural and urban areas. Specifically, we use the estimates of daily calorie needs by age, gender, and physical activity level from the Center for Nutrition Policy and Promotion at the United States Department of Agriculture to compute the necessary adjustments. We assume that rural activities are more strenuous than urban activities and thus require larger calorie intake. Assuming that rural work falls into the "active" activity category, while urban work falls into "sedentary" activity category, we estimate the resulting calorie-intake *premium* in rural areas to be equal to 25%.[25] Therefore, we raise the minimum consumption requirement in rural areas by 11.8%, and reduce it in urban areas by 10.6%, leaving the weighted average of the two areas equal to 50 percent of food consumption.[26] We use

[22] See Herrendorf, Rogerson, and Valentinyi (2013b) for a careful discussion of value added and final expenditure approaches to interpreting the data.

[23] See appendix A.2 for data sources.

[24] See Conference Board.

[25] See http://www.cnpp.usda.gov/sites/default/files/usda_food_patterns/EstimatedCalorieNeedsPerDayTable.pdf

[26] These numbers were obtained by solving the following system of equations for $\bar{a}^R$ and $\bar{a}^U$:

$$\begin{aligned} \bar{a}^R &= (1+\Delta)\bar{a}^U \\ \bar{a} &= s^{RA}\bar{a}^R + (1 - s^{RA}\bar{a}^U), \end{aligned}$$

where Δ is the adjustment factor, $\bar{a}$ is the aggregate minimum agri consumption requirement, and s^{RA} is the rural agri consumption share. We assume $\Delta = 0.25, \bar{a} = 0.5$ and $s^{RA} = 0.47$. The rural agri consumption share, s^{RA}, is approximated as follows.

$$s^{RA} = \frac{MPCE^R * F^R}{MPCE^R * F^R + MPCE^U * F^U},$$

where $MPCE^j$, $j = R, U$ is the monthly per capita consumption expenditures in location j, while F^j, $j = R, U$ is the food share of total consumption expenditures in location j. All numbers were obtained using 1983 NSS data for India. Specifically, we used the following values: $MPCE^R = 200$, $MPCE^U = 250$, $F^R = 62\%$, $F^U = 55\%$.

the same numbers for China in 1988.

Our free parameters are the technology parameters α and β, the training costs τ_U and τ_R, migration cost τ, the sectoral productivity levels A^U, N^R, N^U (we normalize $A^R = 1.5$), the agricultural consumption share θ, the minimum agricultural consumption parameter $\bar{a}$ and the home production of services parameter $\bar{n}$. These eleven parameters are calibrated to jointly match the eleven data moments described above.

We also need to parameterize the process for amenities in rural and urban locations. In particular, $\frac{\bar{\varepsilon}^R}{\bar{\varepsilon}^U}$ characterizes the relative steady-state level of amenities available in rural and urban locations. Since measuring this ratio is not directly observable and no estimates are available in the existing literature, we make the neutral assumption that rural and urban locations do not differ in terms of amenities they offer to their residents in the steady state, i.e. $\frac{\bar{\varepsilon}^R}{\bar{\varepsilon}^U} = 1$.[27]

Parameter ϕ captures the elasticity of available amenities with respect to local population changes, with $\phi < 0$ implying negative externalities associated with population growth due to migration into a location. We choose the value for parameter ϕ, such that the model, in response to the observed sectoral productivity changes, reproduces the observed change in the urban employment share over our sample period.[28] The resulting parameter values are summarized in Table 2.

Table 2: Model parameters, 1983

	parameter	China	India
fixed parameters			
Intertemporal elasticity of substitution	σ	2	2
Relative steady-state amenities level b/n R and U locations	$\frac{\bar{\varepsilon}^R}{\bar{\varepsilon}^U}$	1	1
Productivity in rural agri	A^R	1.5	1.5
estimated parameters			
Labor weight in A sector	α	0.26	0.08
Labor weight in N sector	β	0.50	0.23
Training cost for U households	τ_U	-0.06	0.23
Training cost for R households	τ_R	0.18	0.19
Migration cost	τ	0.63	0.15
Productivity in rural non-agri	N^R	1.18	0.92
Productivity in urban agri	A^U	0.16	0.07
Productivity in urban non-agri	N^U	1.96	1.10
A consumption share	θ	0.40	0.45
Home production of non-agri goods	$\bar{n}$	0.43	0.41
Minimum agricultural consumption	$\bar{a}$	0.67	0.71
Externalities from migration	ϕ	-0.29	-0.05

A few of our estimates are worth discussing further. First, we estimate the migration cost parameter τ to be significantly larger in China than in India. This is not surprising as the data forces this due to the large and persistent urban-rural wage gaps in each sector in China. The

[27] It is easy to see from the locational indifference condition given by equation (3.18) that for a given steady state distribution of the workforce between the urban and rural locations, there is a downward sloping relationship between the migration cost parameter τ and the relative amenities term $\frac{\bar{\varepsilon}^R}{\bar{\varepsilon}^U}$. Specifically, the lower is $\frac{\bar{\varepsilon}^R}{\bar{\varepsilon}^U}$ the higher must τ be to rationalize the given distribution of workers.

[28] It is important to note that we do not impose $\phi < 0$ in our calibration strategy. Rather, we let it be whatever it needs to be in order for the model to match the change in the observed urban employment share during our sample period.

direct data counterpart of the high estimated τ in China would be the Hukou system of household registration which made migration to urban areas very costly for rural households.

Second, the externality parameter ϕ is negative in both countries, but is estimated to be significantly larger (in absolute value) in China than in India. This suggests that congestion externalities associated with migration of rural workers into urban areas are larger in China than in India. The higher estimate for China is explained by its relatively low urbanization pace despite the large and persistent urban-rural wage gaps observed there. In India, on the other hand, the rate of urbanization is roughly in line with the incentives provided by the urban-rural wage gaps there. As a result, the estimated ϕ is significantly lower in India.[29]

Third, our estimated labor share parameters for agriculture are lower than those in non-agriculture for both China and India. This is not unusual for developing countries where the share of land in agriculture is often quite large. Thus, in their study of Indian agriculture, Abler, Tolley, and Kripalani (1994) estimate the labor share in agriculture to be around 60 percent of the labor share in non-agriculture.[30]

Fourth, our parameter estimates imply a negative training cost for urban households in China. In effect, this implies an educational subsidy for urban households. This is less surprising than one might think. There is a large literature on the redistribution of resources in China towards urban areas through a policy of preferential investment in human capital development. For example, Heckman (2005) finds that the fraction of tuition fees per child in household income is twice as high in rural areas compared to urban areas in China. He also documents that per pupil education expenditure by the state varies systematically (positively) by the wealth of the region. Given that the urban regions are wealthier, it implies that state education expenditure is also higher in these regions relative to the poorer rural regions.

It is important to reiterate that our primary focus is to compare the predicted *changes* in the moments of interest from the model with their data counterparts. In doing this we will hold constant the estimated parameters in Table 2. These parameters only allow the model to reproduce the data for the initial date. Our main interest is in evaluating the model in terms of its predictions for changes over time, rather than its fit for the initial date.

[29] In a related paper Dinkelman and Schulhofer-Wohl (2015) use South African data to show that negative congestion externalities of migration are much higher when land markets are missing. Given the more restricted land markets in China as compared to India, the Dinkelman and Schulhofer-Wohl (2015) results provide an independent explanation for why the congestion externality paraemter ϕ is higher in China than in India.

[30] We should note that Tombe and Zhu (2015) estimate the sectoral labor shares in agri and non-agri in China to be significantly higher. Part of the reason for the difference is that they use a different model with intermediate inputs which implies that to estimate the factor share of gross output they need to estimate the sectoral value added shares of gross output and the factor's share of value added. For the factor share of value added, Tombe and Zhu (2015) do not use Chinese data. Instead, they use the numbers estimated for the USA by Caselli and Coleman (2001) who found that the labor share was identical in agri and non-agri for the USA. Without getting into the merits of this assumption for developing countries, we would like to highlight that our method imputes these numbers directly for China and India by matching the data moments for the 1980s.

5.2 Results

How much of the observed dynamics in urban-rural wages in the two countries can be accounted for by the country-specific measured changes in productivity growth in the two sectors? To answer this question we compute the changes in sectoral labor productivity, the dynamics of which during the 1983-2010 period in India and the 1988-2008 period in China are presented in Figure 8. In India agricultural labor productivity increased by 67 percent between 1983 and 2010, while non-agricultural labor productivity increased by 200 percent. The corresponding numbers in China between 1990 and 2008 were 163 percent and 338 percent.

We feed the measured sectoral productivity growth in the two countries into the model while keeping all other parameters unchanged. Specifically, we use the following dynamic equations for sectoral productivities in each country:

$$A_{t+1}^{j} = A_{t}^{j}\left(1 + g_{t}^{A}\right), \quad j = R, U \tag{5.45}$$

$$N_{t+1}^{j} = N_{t}^{j}\left(1 + g_{t}^{N}\right), \quad j = R, U \tag{5.46}$$

where g_t^A and g_t^N are productivity growth rates in agricultural and non-agricultural sectors, respectively. These sectoral productivities are taken as exogenous by households and firms. They are equal to the growth rates in sectoral labor productivities measured in the data (see Figure 8 above), and are assumed to be the same across locations (we relax this assumption in the next section). The results for China are summarized in Table 3, and for India in Table 4.

Several features stand out. First, changes in productivity lead to an increase in urbanization of the labor force in both countries. In particular, the urban employment share increased by 8 percentage points in India between 1983 and 2010, and by 9 percentage points in China between 1988 and 2008. The model reproduces these urbanization dynamics. This is not surprising since the parameter ϕ was calibrated to precisely match this. The part that is noteworthy is that ϕ is negative for both countries, and that it is larger in absolute value for China. These two features indicate: (a) absent these negative congestion externalities on amenities, the model would generate greater urbanization in both countries; and (b) the higher productivity growth in China implied a higher desired urban labor force growth, which necessitated a larger ϕ in absolute value in China to force the model to match the actual increase in the urban employment share.

Second, the share of the workforce employed in agriculture declines in both rural and urban areas in both countries. Thus, the model successfully replicates the patterns of sectoral transformation observed in the data for China and India.

Third, following the productivity shocks, the model predicts that the mean wage gap between urban and rural workers should *decline* in India but *increase* in China. This reproduces the pattern in the data though the model somewhat under-predicts the absolute value of the actual changes in both countries. In India, the overall mean wage gap between urban and rural areas falls by 0.20 in response to sectoral productivity growth, which accounts for 57 percent of the decline in urban-rural wage gap in the data. In China on the other hand, the model predicts a 7 percentage point increase in the overall urban-rural wage gap which is about 35 percent of the actual increase in the data.

Table 3: Model and data: China, 1988 versus 2008

	1988		2008	
	data	model	data	model
employment shares:				
L_U	0.26	0.26	0.35	0.35
L_{RA}	0.79	0.79	0.66	0.57
L_{UA}	0.05	0.05	0.03	0.03
wage gaps:				
within A	1.844	1.826	2.557	1.782
within N	1.290	1.317	1.583	1.613
R between	1.285	1.312	1.238	1.088
U between	0.984	0.947	0.751	0.985
overall mean	1.379	1.626	1.591	1.692
aggregates:				
N/A relative price	1.00	1.00	0.779	0.924
A share of Y	0.17	0.65	0.06	0.47
A share of C	0.33	0.62	0.16	0.46

Table 4: Model and data: India, 1983 versus 2010

	1983		2010	
	data	model	data	model
employment shares:				
L_U	0.22	0.22	0.30	0.30
L_{RA}	0.78	0.78	0.66	0.59
L_{UA}	0.11	0.11	0.07	0.04
wage gaps:				
within A	0.934	0.937	1.027	1.204
within N	1.082	1.080	0.994	1.211
R between	1.962	1.961	1.679	1.405
U between	2.259	2.260	1.709	1.414
overall mean	1.664	1.642	1.310	1.441
aggregates:				
N/A relative price	1.00	1.00	0.714	0.844
A share of Y	0.36	0.71	0.16	0.58
A share of C	0.47	0.68	0.23	0.56

Given that our interest is in explaining the part of the wage gap that is not accounted for by the observed changes in worker attributes like education and skills, we view these results to be indicative of strong success of the model in explaining the aggregate wage patterns.

We should note that the model broadly reproduces the data pattern of a decline in the inter-sectoral wage gap in urban and rural locations in both China and India. In India this decline in the between-sector wage gap was sufficient to compensate for the relatively stable urban-rural wage gap within each sector, thereby reducing the overall urban-rural wage gap. In China however, the decline in the inter-sectoral wage gaps in each location was insufficient to overcome the expansion in the urban-rural wage gaps within each sector, thus inducing a widening of the overall urban-rural wage gap.

Fourth, the model predicts a decline in the relative price of non-agricultural goods in both countries, consistent with the empirical evidence. The model also predicts a fall in the share of agriculture in output and consumption, with the declines being comparable to those found in the data.

Overall, our results suggest that aggregate factors have played an important role in urban-rural dynamics in India and China in the past 20-30 years. Growth of agricultural productivity and an even faster growth of non-agricultural productivity can account for a large share of the sectoral transformation and relative price dynamics in both countries. The same forces also account for a large part of the observed wage convergence between urban and rural areas in India and predict some divergence in urban-rural wages in China. Furthermore, these factors induce within-sector and between-sector wage adjustments that are consistent with the data.

To understand these results for urban-rural wage gaps, recall that the model relies on two competing effects – the demand effect, which leads to wage convergence; and the urbanization effect which leads to wage divergence. Whether urban and rural wages converge or diverge depends on the relative strengths of these two effects. The urbanization effect is stronger in India where the estimated migration costs and negative migration externalities are smaller. In contrast, for China we estimate larger migration costs and higher negative externalities arising from migration. As a result, the urbanization effect is weaker and urban-rural wage gap rises over time.

5.2.1 Agglomeration externalities in production

The baseline model that we developed introduced a negative congestion externality of migration on urban amenities. That formalization ignored a second often discussed externality of migration which is its positive effect on aggregate productivity. This positive production externality is typically proposed as an explanation for the concentration of economic activity in locations as well as the growth of cities. This is potentially an important margin for understanding the process of urbanization, so we next explore the role of positive agglomeration externality in production.

We postulate that urban total factor productivity growth gets an additional boost from growth in the urban labor force. Specifically, we assume that

$$1 + g_t^{Uk} = \left(1 + X_t^k\right)\left(1 + g_t^{Rk}\right), \quad k = A, N \tag{5.47}$$

where

$$1 + X_t^k = \left(\frac{L_t^U}{L_{t-1}^U}\right)^{\phi_k}, \quad k = A, N \tag{5.48}$$

Clearly, as long as there is positive migration into urban areas so that $X^k > 0$, productivity *growth* in both sectors is going to be higher in urban areas relative to rural locations.[31]

There are two interesting special cases here. First, for $\phi_A = \phi_N$ the urban production externality is identical across sectors. Second, when $\phi_A = 0$ the externality only affects the non-agricultural sector while agricultural productivities grow at the same rate in urban and rural locations. Notice

[31] Our assumption that urban productivity growth depends on urban population growth is consistent with an environment where productivity growth depends upon ideas that are carried by individuals. Implicitly, the formulation is a stand-in for environments where faster population growth in a location induces greater exchange of ideas and consequently faster TFP growth.

that since $L_t^U = L_{t-1}^U + M_t$, i.e., the urban population at time t is the sum of the urban population at $t-1$ plus the new migrants at t, equation (5.48) can be written as

$$1 + X_t^k = \left(1 + \frac{M_t}{L_{t-1}^U}\right)^{\phi_k}, \quad k = A, N$$

Migration from rural to urban areas now has two effects. On the one hand, negative congestion externalities reduce the level of urban amenities according to equation (3.7). This is unchanged from our baseline case. In addition, the process of urban migration now also raises productivity in urban locations relative to their rural counterparts. Thus, productivity growth becomes urban-biased in this case.

Our identification strategy for the parameters of the model is the same as before: we calibrate the parameters of the model to target the same set of moments in the initial period. We then hit the model with the measured average sectoral productivity growths during the sample period. Notice that the average sectoral productivity growths for the country as a whole are given by

$$1 + g_t^k = s_t^{Rk}\left(1 + g_t^{Rk}\right) + \left(1 - s_t^{Rk}\right)\left(1 + g_t^{Uk}\right), \quad k = A, N$$

where s^{Rk} is the fraction of sector-k labor working in rural locations. Hence, the average gross sectoral growth rate is just the weighted average of the corresponding location-specific sectoral growth rates. We measure both g^k and s^{Rk} from the data. We assume that $\phi_A = \phi_N = -\phi$ and calibrate the parameter ϕ to match the net rural-to-urban migration flows during the sample period.[32] This gives a value of $\phi = -0.31$ in China and $\phi = -0.055$ in India. These parameter estimates imply that the observed increase in the urban employment shares induced a 10% boost to urban productivity in China, and 1.7% boost to urban productivity in India.[33]

Table 5 report the changes in the relevant variables predicted by the model under agglomeration externalities as well as those under the baseline case where these production externalities are absent. The table makes clear that a more rapid increase in relative urban productivity stalls the wage convergence in both countries. For instance, in India the resulting wage convergence between urban and rural labor is smaller, with the gap declining by 0.18 compared to 0.20 in the case of shocks that are symmetric across locations. In China, urban and rural wages are diverging by 0.11 instead of 0.07. Crucially, the wage gaps that change the most in both countries are the urban-rural wage gaps within sectors. Since we have assumed that agglomeration effects are symmetric across sectors, the inter-sectoral wage gaps remain relatively unaffected by the introduction of agglomeration externalities.

These results are best understood by noting that the introduction of agglomeration externalities

[32] This restriction forces the amenities congestion externality parameter and the agglomeration productivity externality parameters to be the same in absolute value but of opposite signs. Hence, negative amenities externalities would coincide with positive agglomeration production externalities. This restriction ties our hands in terms of fitting the data but also provides some discipline on the calibration exercise due to the relaitve paucity of independent estimates of these effects.

[33] Note that our specification implies that $1 + g^{Rk} = \frac{1+g^k}{1+\left(1-s^{Rk}\right)X^k}$, $k = A, N$ which can be used to infer the location-specific productivities by substituting in the measured values for g^k, X^k and s^{Rk} from the data.

in urban production has two effects. On the one hand, the rural-to-urban migration induces greater urban population growth and density. This raises urban productivity in both sectors which increases the relative wages of urban workers, thereby widening the urban-rural wage gap. On the other hand, a greater incentive for migration, all else equals, drives down the wage gap due to the increase in relative urban labor supply. In our calibration of the two countries, the first effect dominates and the wage gap expands relative to the case where productivity growth is symmetric across locations.

We view these results as indicative of the robustness of our baseline model to allowing for positive externalities of migration through agglomeration effects in production. However, they also resonate particularly for China where a number of authors have found evidence of location biased factor allocation. For instance, in China rates of return on capital investment tend to be higher in smaller cities and rural areas, suggesting that urban locations are typically favoured for capital allocation by the government. This raises the productivity of urban workers relative to workers in rural areas (see Jefferson and Singh (1999); Bai, Hsieh, and Qian (2006). Given that the baseline model was underpredicting the wage divergence in China, the addition of agglomeration effects of migration on urban productivity appears to provide one rationalization for the higher observed wage divergence in the data. It also provides a background rationalization for the evidence in Jefferson and Singh (1999) and Bai, Hsieh, and Qian (2006).

Table 5: Changes under agglomeration production externalities

	Baseline		Agglomeration	
	China	India	China	India
changes in employment shares:				
L_U	0.09	0.08	0.09	0.075
L_{RA}	-0.22	-0.19	-0.19	-0.187
L_{UA}	-0.02	-0.07	-0.02	-0.067
changes in wage gaps:				
within A	-0.043	0.267	0.004	0.289
within N	0.296	0.131	0.332	0.147
R between	-0.224	-0.556	-0.220	-0.551
U between	0.039	-0.846	0.038	-0.849
overall mean	0.066	-0.201	0.111	-0.177
changes in aggregates:				
N/A relative price	-0.076	-0.156	-0.095	-0.072
A share of Y	-0.18	-0.13	-0.17	-0.129
A share of C	-0.16	-0.12	-0.16	-0.119

Note: The results under Baseline report the changes in the variables of interest predicted by the model in response to productivity changes (for India, see Table 4; for China see Table 3). The results under Agglomeration report the results of introducing an urban agglomeration effect on productivity due to migration while keeping overall sectoral productivity growth unchanged as under the baseline case.

5.3 Experiments

The growth experience of China and India are recognized to differ from each other in two key aspects. First, China's growth takeoff was much sharper with growth rates being significantly higher than in

India. Second, the role of the state in controlling and directing labor flows across locations through the Chinese household registry system (the Hukou) was significantly greater in China relative to India. The Hukou system effectively raised the cost of labor migration from rural to urban locations. How important were these two factors for understanding the differences in the urban-rural dynamics in the two countries? The model allows us to conduct two counterfactual experiments to address these questions. We first derive the counterfactual path of urban-rural inequality in India if its growth rate had been like China. Next, we ask what would happen to urban-rural inequality in China if migration costs were reduced to India's levels.

5.3.1 India growing like China

For this experiment we use the model calibrated to India and feed into it the measured sectoral productivity growth for China, keeping all other parameters unchanged. Specifically, we assume that agricultural labor productivity increased by 163% and non-agricultural labor productivity increased by 338% in India. The results are presented in column labelled "Exp1: High Growth, India" of Table 6. The table reports the changes in the relevant indicators as well as the corresponding changes in those variables under the baseline case.

Under the faster sectoral productivity growth, the model predicts a larger flow of migrants from rural to urban areas, leading to the urban labor share rising to 0.33 as opposed to 0.30 in the benchmark model and in the data for India. The labor reallocation from agricultural activities is also larger in this case with the agricultural employment share declining from 0.78 to 0.5 in rural areas and from 0.11 to 0.03 in urban areas. Given the larger urbanization effect, there is a greater urban-rural wage convergence with the overall mean wage gap contracting from 1.642 in 1983 to 1.388 in 2010 implying a 25 percentage point decline as opposed to the 20 percentage point decline in the benchmark case.

Notice that the effect on relative prices now, however, differs from the benchmark result. The relative price of non-agricultural goods *rises* when India grows like China. This is because the "demand effect" is also stronger when India's productivity rises faster. The greater increase in income induces a larger decline in the relative demand for the agricultural good which, in turn, reduces the relative price of agriculture (a rise in p). This effect is now strong enough to more than offset the positive supply effect arising from rural to urban migration and consequently causes a fall in the equilibrium relative price of the agricultural good.

5.3.2 China migration costs as in India

In this experiment we reduce the migration externalities in China to their levels in India. This is equivalent to reducing the migration cost. The results of this experiment are presented in the column labelled "Exp2: Low ϕ, China" of Table 6. Not surprisingly, lower costs lead to larger migration flows predicted by the model, with the urban employment share rising to 0.44 in 2008. This migration effect is large enough to overturn the urban-rural wage divergence in China. With lower migration externalities the urban-rural wage gap declines by 0.32, i.e. the model predicts wage convergence

Table 6: Experiments

	Baseline		Exp1: High growth	Exp2: Low ϕ
	China	India	India	China
changes in employment shares:				
L_U	0.09	0.08	0.11	0.18
L_{RA}	-0.22	-0.19	-0.28	-0.18
L_{UA}	-0.02	-0.07	-0.08	-0.02
changes in wage gaps:				
within A	-0.043	0.267	0.344	-0.456
within N	0.296	0.131	0.192	-0.076
R between	-0.224	-0.556	-0.747	-0.230
U between	0.039	-0.846	-1.055	0.035
overall mean	0.066	-0.201	-0.254	-0.323
changes in aggregates:				
N/A relative price	-0.076	-0.156	0.068	-0.163
A share of Y	-0.18	-0.13	-0.18	-0.18
A share of C	-0.16	-0.12	-0.16	-0.16

Note: Experiment1 applies China's sectoral productivity growth to India calibration; Experiment2 uses the migration externality parameter estimated for India ($\kappa = -0.05$) in China's calibration.

over time. Moreover, all conditional wage gaps decline.

This experiment suggests that bringing the migration costs in China down to their levels in India would produce a significant reduction in wage inequality in China. Put differently, the model suggests that restrictions on labor mobility were a key fact behind the widening urban-rural wage inequality in China during this period.

5.4 Testing the mechanism

The analytical results and the quantitative experiments presented above provide us with several key predictions about the relationship between wage gaps, productivity and urbanization in the model. First, Proposition 3 indicates that an increase in productivity is associated with a widening of the urban-rural wage gap when there is no migration across locations. A generalization of this is that conditional on a given size of the urban labor force, an increase in productivity widens the urban-rural wage gap. Second, Propositions 2 and 1, and the quantitative results in Table 6 show that for a given level of productivity, a decrease in migration costs is accompanied by greater urbanization and a narrowing of the urban-rural wage gap.

To test the model mechanism we collected state-level data on urban-rural wage (or income) gaps, urban employment and sectoral labor productivity in India and China. Specifically, for India we were able to put together a dataset covering 27 states for year 1983, 2000 and 2010, while for China we collected data on 30 provinces over 1990, 1995, 2002, 2007 and 2008 period. For India we used urban-rural wage gaps from the NSSO dataset, while for China we used urban-rural income gaps from Provincial Statistical Yearbooks. See Appendix for more details on the data sources and computations. We then estimated a regression of wage gaps in India (income gaps in China) on urbanization (as measured by urban employment share) and productivity (as measured by agricultural and non-agricultural labor productivity).

The regression results are presented in Table 7. Consistent with the predictions of the model, we find that urbanization tends to reduce urban-rural wage/income gap in both countries; while agricultural productivity tends to widen the same gaps. The effect of non-agricultural productivity is consistent with the model's predictions in China but goes in the wrong direction in India. Overall, we view these results as independent evidence supportive of the basic mechanisms formalized in the model.

Table 7: Testing model mechanism

	India U-R wage gap	China U-R income gap
Urban employment share	-1.317***	-1.574***
	(0.288)	(0.287)
Agri productivity	0.257**	1.033***
	(0.127)	(0.352)
Non-agri productivity	-1.463***	0.094***
	(0.542)	(0.036)
N	77	142

Note: For India the regressions are at the state level, while for China they are at the provincial level. Sectoral productivity is obtained as a ratio of sectoral output to sectoral employment. Regressions also include a constant (not reported).

6 Conclusion

This paper has studied the experience of China and India over the past thirty years to form a better understanding of the process of structural transformation of countries during the development process. A unique aspect of our work is that we focused on both quantities and prices. In addition, we have examined the process of structural transformation jointly with the process of urbanization. Our data analysis has revealed some interesting contrasts between China and India during this period. While the structural transformation experience of the two economies has been quite similar, the movements in wages have not. Specifically, while urban-rural wage gaps widened in China, they have contracted in India during this period. Interestingly, this has occurred in the backdrop of similar qualitative movements in the inter-sectoral wage gaps as well as in the relative sectoral prices of goods. This evidence suggests to us that the standard practice of equating the agricultural sector with rural locations and non-agriculture with urban locations is not an innocuous abstraction. Indeed, a significant part of the structural transformation from agriculture to non-agriculture occurs *within* rural locations.

To explain the contrasting trends in the two countries, the paper formalized a two-sector, two-location overlapping generations model of structural transformation. Our model generates structural transformation through non-homothetic preferences and growth in agricultural productivity. We have showed that the model, calibrated to China and India, can generate the opposing movements in the urban-rural wage gaps observed in the two economies. Counterfactual exercises on our baseline model suggest that the restrictions on labor mobility in China from rural to urban areas were a key factor behind the widening urban-rural wage gaps there. An important ancillary result of the model is that it can account for the fact that the relative price of the non-agricultural good declined in both China and India during this period. It is important to note that this data fact is at odds with the rise in this relative price that is implied by standard non-homothetic models of structural transformation.

The key feature of our model that allows it to reproduce the wage and price movements is the endogenous urbanization margin embedded in it. This introduces an endogenous change in the relative urban labor supply which both tends to reduce the relative price of urban labor (and hence reduces the urban-rural wage gap) and also reduces the relative price of non-agricultural goods which are intensively produced in urban areas. Using cross-province and cross-state data from China and India, respectively, we have shown independent evidence in support of these mechanisms embedded in the model.

We believe that our results suggest that the redistributional and allocational implications of structural transformation cannot be adequately analyzed without explicitly taking into account the accompanying migration and urbanization that is generic to this process. The results also suggest that any analysis of the implications of structural transformation should include an explicit investigation of prices of both factors and goods in order to form a better understanding of the mechanics of the process as well as for devising appropriate analytical structures that best describe them. A larger cross-country study along these lines would appear to be a fruitful avenue for future work.

References

Abler, D., G. Tolley, and G. Kripalani (1994): *Technical change and income distribution in Indian agriculture.* Westview Press, Inc.

Acemoglu, D., and V. Guerrieri (2008): "Capital Deepening and Nonbalanced Economic Growth," *Journal of Political Economy*, 116(3), 467–498.

Allen, T., and C. Arkolakis (2014): "Trade and the Topography of the Spatial Economy*," *The Quarterly Journal of Economics*, 129(3), 1085–1140.

Anand, R., and E. Prasad (2010): "Optimal Price Indices for Targeting Inflation under Incomplete Markets," IZA Discussion Papers 5137, Institute for the Study of Labor (IZA).

Bai, C.-E., C.-T. Hsieh, and Y. Qian (2006): "The Return to Capital in China," Working Paper 12755, National Bureau of Economic Research.

Baumol, W. J. (1967): "Macroeconomics of unbalanced growth: the anatomy of urban crisis," *The American Economic Review*, 57(3), 415–426.

Bryan, G., and M. Morten (2016): "Economic Development and the Spatial Allocation of Labor: Evidence From Indonesia," Working paper, Stanford University.

Caselli, F., and J. Coleman (2001): "The U.S. Structural Transformation and Regional Convergence: A Reinterpretation," *Journal of Political Economy*, 109(3), 584–616.

DiNardo, J., N. M. Fortin, and T. Lemieux (1996): "Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach," *Econometrica*, 64(5), 1001–44.

Dinkelman, T., and S. Schulhofer-Wohl (2015): "Migration, congestion externalities, and the evaluation of spatial investments," *Journal of Development Economics*, 114(C), 189–202.

Duranton, G., and D. Puga (2004): "Micro-foundations of urban agglomeration economies," in *Handbook of Regional and Urban Economics*, ed. by J. V. Henderson, and J. F. Thisse, vol. 4 of *Handbook of Regional and Urban Economics*, chap. 48, pp. 2063–2117. Elsevier.

Firpo, S., N. M. Fortin, and T. Lemieux (2009): "Unconditional Quantile Regressions," *Econometrica*, 77(3), 953–973.

Gollin, D., D. Lagakos, and M. Waugh (2012): "The Agricultural Productivity Gap in Developing Countries," Working paper, Arizona State University.

Gollin, D., S. Parente, and R. Rogerson (2002): "The Role of Agriculture in Development," *American Economic Review*, 92(2), 160–164.

Heckman, J. J. (2005): "China's Human Capital Investment," *China Economic Review*, 16, 50–70.

Herrendorf, B., R. Rogerson, and A. Valentinyi (2013a): "Growth and Structural Transformation," *Handbook of Economic Growth, forthcoming.*

——— (2013b): "Two Perspectives on Preferences and Structural Transformation," *American Economic Review, forthcoming.*

Herrendorf, B., and T. Schoellman (2015): "Wages, Human Capital, and the Allocation of Labor across Sectors," Working paper, Arizona State University.

Hnatkovska, V., and A. Lahiri (2015): "Rural and Urban Migrants in India: 1983-2008," *World Bank Economic Review*, 29, S257–S270.

Jefferson, G., and I. Singh (1999): *Enterprise Reform in China: Ownership, Transition, and Performance*, A World Bank Publication. Oxford University Press.

Kongsamut, P., S. Rebelo, and D. Xie (2001): "Beyond Balanced Growth," *Review of Economic Studies*, 68(4), 869–882.

Lagakos, D., and M. Waugh (2012): "Selection, Agriculture, and Cross-Country Productivity Differences," *American Economics Review, forthcoming.*

Laitner, J. P. (2000): "Structural Change and Economic Growth," *Review of Economic Studies*, 67(3), 545–561.

LUCAS, R. E., AND E. ROSSI-HANSBERG (2002): "On the Internal Structure of Cities," *Econometrica*, 70(4), 1445–1476.

MORTEN, M. (2016): "Temporary Migration and Endogenous Risk Sharing in Village India," NBER Working Papers 22159, National Bureau of Economic Research, Inc.

MUNSHI, K., AND M. ROSENZWEIG (2016): "Networks and Misallocation: Insurance, Migration, and the Rural-Urban Wage Gap," *American Economic Review*, 106(1), 46–98.

NGAI, L. R., AND C. A. PISSARIDES (2007): "Structural Change in a Multisector Model of Growth," *American Economic Review*, 97(1), 429–443.

QU, Z. F., AND Z. ZHAO (2008): "Urban-Rural Consumption Inequality in China from 1988 to 2002: Evidence from Quantile Regression Decomposition," IZA Discussion Papers 3659, Institute for the Study of Labor (IZA).

TOMBE, T., AND X. ZHU (2015): "Trade, Migration and Productivity: A Quantitative Analysis of China," Working Papers tecipa-542, University of Toronto, Department of Economics.

WU, X., AND J. M. PERLOFF (2005): "China's Income Distribution, 1985-2001," *The Review of Economics and Statistics*, 87(4), 763–775.

YOUNG, A. (2012): "Inequality, the Urban-Rural Gap and Migration," Working paper, London School of Economics.

A Appendix: Not for publication

A.1 Data

A.1.1 India

The National Sample Survey Organization (NSSO), set up by the Government of India, conducts rounds of sample surveys to collect socioeconomic data. Each round is earmarked for particular subject coverage. We use the latest six large quinquennial rounds – 38(Jan-Dec 1983), 43(July 1987-June 1988), 50(July 1993-June 1994), 55(July 1999-June 2000), 61(July 2004-June 2005) and 66(July 2009-June 2010) on Employment and Unemployment (Schedule 10). Rounds 38 and 55 also contain migration particulars of individuals. We complement those rounds with a smaller 64th round(July 2007-June 2008) of the survey since migration information is not available in all other quinquennial survey rounds.

The survey covers the whole country except for a few remote and inaccessible pockets. The NSS follows multi-stage stratified sampling with villages or urban blocks as first stage units (FSU) and households as ultimate stage units. The field work in each round is conducted in several sub-rounds throughout the year so that seasonality is minimized. The sampling frame for the first stage unit is the list of villages (rural sector) or the NSS Urban Frame Survey blocks (urban sector) from the latest available census. The NSSO supplies household level multipliers with the unit record data for each round to help minimize estimation errors on the part of researchers. The coding of the data changes from round to round. We re-coded all changes to make variables uniform and consistent over the time.

In our data work, we only consider individuals that report their 3-digit occupation code and education attainment level. Occupation codes are drawn from the National Classification of Occupation (NCO) – 1968. We use the "usual" occupation code reported by an individual for the usual principal activity over the previous year (relative to the survey year). The dataset does not contain information on the years of schooling for the individuals. Instead it includes information on general education categories given as (i) not literate -01, literate without formal schooling: EGS/ NFEC/ AEC -02, TLC -03, others -04; (ii) literate: below primary -05, primary -06, middle -07, secondary -08, higher secondary -10, diploma/certificate course -11, graduate -12, postgraduate and above -13. We aggregate those into five similarly sized groups as discussed in the main text. We also convert these categories into years of education. The mapping we used is discussed in the main text.

The NSS only reports wages from activities undertaken by an individual over the previous week (relative to the survey week). Household members can undertake more than one activity in the reference week. For each activity we know the "weekly" occupation code, number of days spent working in that activity, and wage received from it. We identify the main activity for the individual as the one in which he spent maximum number of days in a week. If there are more than one activities with equal days worked, we consider the one with paid employment (wage is not zero or missing).

Workers sometimes change the occupation due to seasonality or for other reasons. To minimize the effect of transitory occupations, we only consider wages for which the weekly occupation code coincides with usual occupation (one year reference). We calculate the daily wage by dividing total wage paid in that activity over the past week by days spent in that activity.

Lastly, we identify full time workers in our dataset. We assume that an individual is a full time worker if he is employed (based on daily status code) for at least two and half days combined in all activities during the reference week. We drop observations if total number of days worked in the reference week is more than seven.

A.1.2 China

The Chinese Household Income Project (CHIP) is organized by Chinese and international researchers, with the assistance from National Bureau of Statistics (NBS), to study the distribution of personal income in both rural and urban areas in China. There are five waves available: 1988, 1995, 2002, 2007 and 2008. The last two waves were also part of the RUMiC (Rural-Urban Migrants in China) survey project. All waves contain separately a rural and urban survey, on which we base our definition of rural and urban.

Our sample of full-time workers includes observations with working status as employed or self-employed and total annual hour larger than 1900 hours. The status variable categories vary across years. We re-coded it to a consistent 8 categories: Employed, Self-employed, Unemployed, Retired, Homemaker, Disabled, Student/pre-school, and Others. For years with a separate self-employment indicator, we made sure it lines up with status. All years except for 1988 contain hour information. The 1995, 2007, and 2008 waves give hours per week. We first top code the observations larger than 100 to 100 hours, then multiply the hour per week statistics by 50 weeks, assuming two weeks of national holiday in China. In 2002, we divided the annual hour by 50, top code it, and then multiply back 50, to make the numbers consistent with other years. For the 1988 rural survey, we include all employed and self-employed people with non-missing wages. For the 1988 urban survey we dropped temporary workers (about 340 of them) from the sample of employed or self-employed.

A.2 Consumption moments: Data and calculations

A.2.1 Consumption value added

For India we used sectoral value added from GDP by economic activity data from Statement 10 of National Accounts Statistics provided by the Ministry of Statistics and Programme Implementation (MOSPI) of Government of India. Investment is measured as gross capital formation, and was obtained from Statement 20 of National Accounts Statistics provided by MOSPI. Both value added and investment is in constant 1999-00 prices and can be accessed from
http://mospi.nic.in/Mospi_New/site/India_Statistics.aspx?status=1&menu_id=43.

For China the national level agriculture and non-agriculture employment and GDP was obtained from the National statistics yearbook 2013. GDP is in constant 2004 prices.

A.3 Aggregate and state/provincial data

The series for the relative prices of non-agricultural goods (relative to agricultural good) were obtained using nominal and real output series from the National Accounts Statistics provided by the Ministry of Statistics and Programme Implementation (MOSPI) of Government of India and the National Statistical Yearbook in China.

A.3.1 China

For the provincial aggregate data for China, our primary source of data is from the China Compendium of Statistics, which is published in 2009 to celebrate the 60th anniversary of PRC and contains statistics from 1949-2008. Whenever the information needed is missing in the Compendium, we complement it by check the provincial Statistics Yearbooks in various years so that in the end our data could expand the 20 years between 1988-2008.

Sectoral GDP: this information solely comes from the China Compendium of Statistics. The Compendium reports a nominal series of sectoral GDP and GDP index that equals 100 in 1952. There are three sectors: the Primary sector, which includes agriculture, fishing and husbandry; the secondary sector, which includes construction and manufacturing; and the tertiary sector, which is the service sector. To get our own real GDP, we multiply the 1952 level nominal GDP to the GDP index in each year. In this way, we are able to compare GDP across time and provinces. Finally, we define the real GDP in the primary sector as our GDP agriculture, and sum up the real GDP in the secondary and tertiary sectors as our GDP non-agriculture.

Urban (rural) employment: this information is obtained directly from the China Compendium of Statistics.

Urban (rural) population: this information mainly comes from the Compendium, but with missing years for 7 provinces out of the 31 (Hebei, Jilin, Zhejiang, Fujian, Guangdong, Sichuan, and Shaanxi). We supplement the missing data from the provincial yearbooks. In the end, we could get the urban-rural population for all the provinces except for Hebei, Jilin, Guangdong, and Chongqing, which only have agrarian and non-agrarian population (calculated from the hukou status). For these four provinces, we used the non-agrarian population as the number for urban population, and the agrarian population as the rural one.

Urban (rural) per capita income: this information is obtained from the provincial yearbooks in various years. The information is usually under the section for "People's Livelihood". The urban income is reported as per capita disposable income in the urban area, and the rural income is reported as per capita net income in the rural area.

Urban (rural) CPI: this information is obtained from the Compendium. For Beijing and Shanghai, there is only an aggregate CPI series. We assigned this series as both urban and rural CPI. For Tianjin and Chongqing, there is only urban CPI. Similarly, we assigned the urban CPI to the rural one. Therefore, for these four provinces, they have the same CPI for urban and rural. The Shaanxi province doesn't have rural CPI for 1979-1994, we replace that by the aggregate CPI series. The raw CPI index has last year as base. We convert them to have year 1995 as the common base year.

A.3.2 India

For state-level data we rely on the following sources.

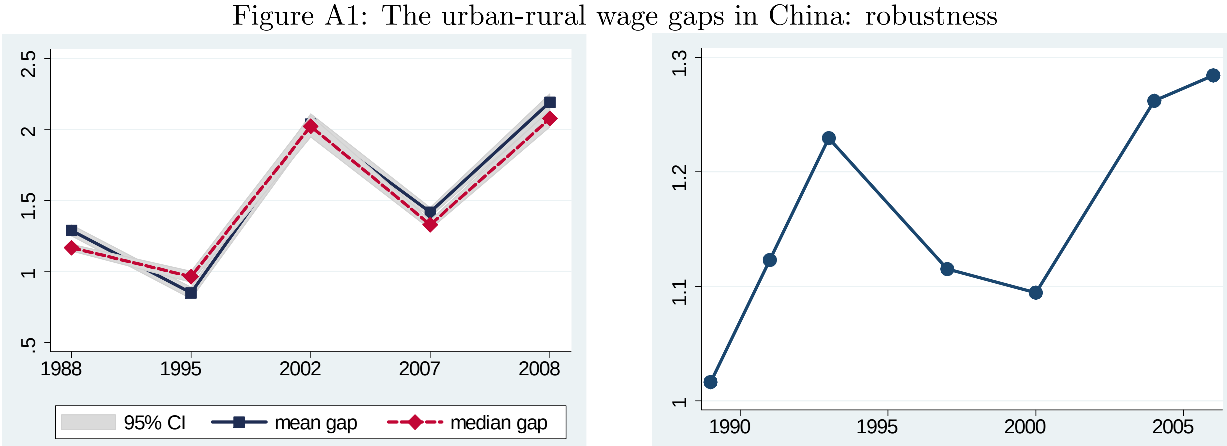
Sectoral GDP by state: This information comes from the online database of the India Government Ministry of Statistics and Programme Implementation. The data comes in four set of years: 1980-1996, 1993-2002, 1999-2007, and 2004-2012, in terms of both current and constant prices. We use the constant price series from each dataset, and rescale them so that the base year is the same as the last dataset (the 2004-2012 one), which is 2004. To do so, we first rescale the 1999-2007 data set for each province-sector series, so that the 2004 GDP value is consistent across the two data sets. Then, we rescale the 1993-2002 data set to match the 1999 GDP value in the later data sets, and so on. In this way, each province sector series is at constant 2004 price.

Sectoral employment information by state: from NSS.

A.4 Robustness: China

To further examine the robustness of the wage and income patterns for China, Figure A1 plots the urban-rural wage gaps computed from two other sources: CHIP dataset using family income information (panel (a)), and China Health and Nutrition Survey (panel (b)).[34] Panel (a) shows the mean and median gaps in (per capita) annual family income of urban and rural households in China since 1988, while panel (b) constructs the ratio of mean urban to rural wages over 1989-2006 period. Both plots reveal the same pattern of widening income and wage gaps between urban and rural Chinese workers over the past three decades.

Figure A1: The urban-rural wage gaps in China: robustness



(a) CHIP: mean income gap (b) China Health and Nutrition Survey: mean wage gap

Notes: Panel (a) shows the ratio of mean income in urban areas to mean income in rural areas; and the ratio of median income in urban areas to median income in rural areas together with the 95% confidence intervals using CHIP dataset; Panel (b) reports the ratio of mean wages in urban and rural areas in China Health and Nutrition Survey.

[34] Like the CHIP dataset, the China Health and Nutrition Survey dataset contains individual- and household-level survey data. However, it is significantly smaller than CHIP.