Human Capital and Structural Transformation - The Atypical Case of India

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Abstract

India's structural transformation has taken an unusual path wherein the productivity and wages in services are higher and growing relative to manufacturing, and yet employment is increasing faster in manufacturing. Two facts indicate that this is not a result of barriers to reallocation of labor. (1) Any costs created by pro-labor laws, previously cited as the main factor underlying stagnant manufacturing, are swamped by the excess supply of labor. (2) Mincerian sectoral returns to human capital explain majority of the wage-gap between sectors. We provide evidence and develop a model to argue that low levels of human capital, due to costly skill accumulation, force workers to flow faster into the less skill-intensive manufacturing sector.

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1 Introduction

Figure 1: Sectoral Shares of GDP and Employment in India

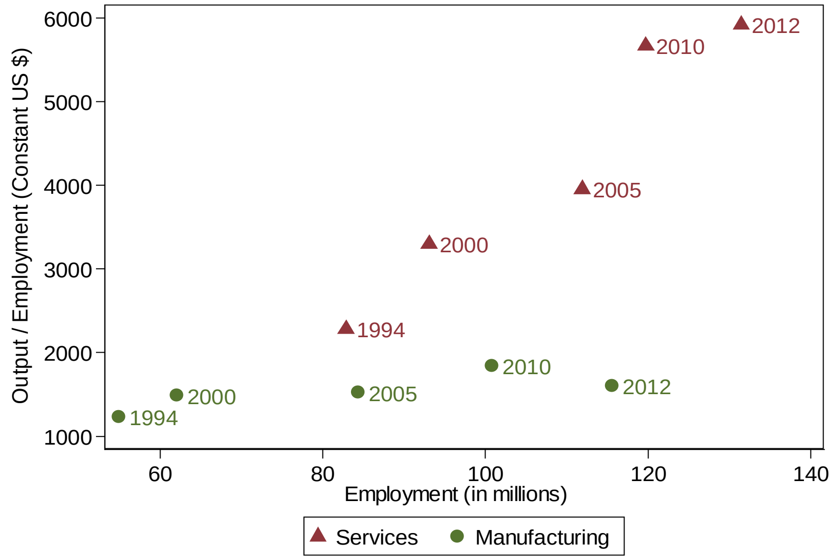
This paper examines why structural transformation in India has followed an atypical pattern. Between 1970 and 2013, services' share in India's GDP grew from 34% to 53% while that of manufacturing grew from 19% in 1970 to only 27% by 2005, and began declining thereafter (see Figure 1(a)). This may indicate that India has entered the second stage of structural transformation where manufacturing share declines and is replaced by services. But employment trends in the two sectors suggest otherwise. Employment grew more in manufacturing than in services; 9 percentage points versus 4 percentage points, respectively, over 1994-2012 (see Figure 1(b)). The result, as Figure 2 shows, is that the aggregate labor productivity (output/employment) has grown rapidly in services while stagnating in manufacturing.

The striking difference between services and manufacturing productivity trends makes India an outlier in international comparisons. Figure 3 contrasts the productivity of services relative to manufacturing in India to that in several other Asian, Latin American, and OECD countries. The figure shows that while other Asian and Latin American countries have lower relative service productivities than OECD countries, it is the opposite in India. Further, none of the other countries sees either the level or the growth of relative service productivity as witnessed in India, where services are nearly four times as productive as manufacturing in 2012.

In this context, we address two questions: Why is the productivity gap between services and manufacturing large and growing? and yet Why is employment growing faster in the stagnant manufacturing sector? One may be tempted to conclude that these trends reflect large barriers to intersectoral labor movement. We provide evidence, however, that this is not a significant underlying factor. Instead, skill deficits in the large labor supply compell workers to find jobs in the less skill-intensive manufacturing sector.

In principle, reallocation of labor from manufacturing to services may be restricted by two frictions that have received attention in previous literature - pro-labor laws and low inter-regional mobility. Several studies argue that pro-labor laws increase labor costs, causing manu-

Figure 2: Labor Productivity in Services and Manufacturing in India



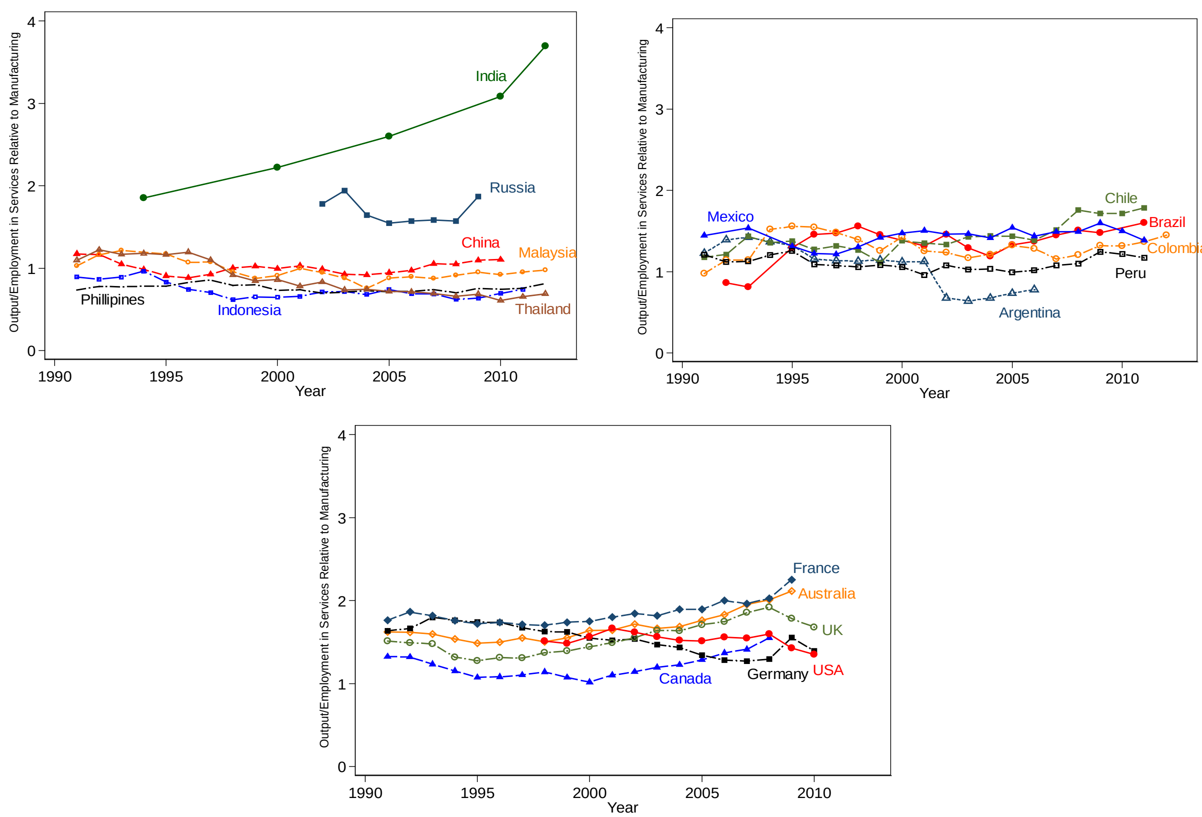


Figure 3: International Comparison: Services Productivity Relative to Manufacturing

facturing to become unproductive and stagnate (see Besley and Burgess (2004) and Aghion et al. (2008), among others). We document two facts that negate the importance of such laws for

India's structural transformation. First, we use an accounting framework (similar to Hsieh and Klenow (2009)) to measure labor distortions faced by firms in the two sectors that potentially cause misallocation of resources within and between manufacturing and services. This analysis shows that wages are below the marginal product of labor for firms in both sectors, i.e., labor is effectively subsidized. Further, labor is subsidized more in manufacturing than in services. This suggests an excess supply of labor in both sectors, more so in manufacturing, that swamps any extra costs created by the pro-labor laws. Second, following Herrendorf and Schoellman (2015), we construct sectoral measures of human capital using standard Mincerian regressions and find that the wage gap between the two sectors is almost entirely explained by differences in returns to human capital. This finding again de-emphasizes the role of pro-labor laws or other barriers causing inefficient labor allocation.

To understand the role of low inter-regional mobility[1] in structural transformation, we rely on the findings of Hnatkovska and Lahiri (2014) who document remarkable wage convergence between rural and urban areas in India. They do not find migration of workers to be a major factor underlying this convergence since it continues to be low, as shown in previous studies. Instead, they show that labor supply has grown faster in urban than in rural India, driven by rapid urban agglomeration so that previously rural areas have now become urban. Thus, despite low inter-regional mobility, structural transformation has proceeded with rural workers becoming urban and the wage-gap between the two closing.

Having ruled out inefficient allocation of labor between manufacturing and services, we focus on the mis-match between demand and supply of skills. We establish, empirically and theoretically, that while there is an excess supply of unskilled labor, there is an excess demand for skilled labor. This, in turn, entails a faster flow of unskilled labor in the less skill-intensive manufacturing sector and lowers its productivity. Services sector is more skill-intensive as seen from its educational composition which is considerably more skewed towards college and high-school graduates than manufacturing. However, the labor force continues to be largely unskilled, with only 10% having a college degree. Many reports highlight the poor enrollment rates, high dropout rates and low quality of both primary and higher education. Basant and Sen (2014) document that less than 9% of 15-29 year olds were enrolled in higher education in 2009. The percentage was a mere 3% in 1999. A report from the World Bank finds that 8.1 million children (5% of all children) were out of school in 2009 but only 40% of adolescents attend high school. A Brookings study argues that quality of primary education is quite poor and documents that 50% of children in grade 5 cannot read a text at the level of grade 2. Thus, there is severe skill-deficit in labor supply. This skill-deficit is also suggested by reports of McKinsey and a 2011 Wall Street Journal article that highlight firms lamenting the lack of a skilled workforce to fill their positions.

Motivated by this empirical evidence, we develop a model to examine and quantify the importance of costly investment in human capital for the unusual path of structural change

[1] See Topalova (2010) and Munshi and Rosenzweig (2014).

witnessed in India. The model, that builds on the framework suggested by Eeckhout and Kircher (2012), includes heterogeneous firms that post vacancies for high and low skilled workers and heterogeneous workers who look for jobs at firms in manufacturing and service sectors. The skill levels of individuals are endogenous. Households make human capital investment decisions based on cost and expected returns, given the probabilities of finding jobs in the two sectors. The model is work in progress and will be presented in detail in our next draft.

This paper is most closely related to Herrendorf and Schoellman (2015) who use Mincerian regressions to show for thirteen countries, including India, that the wage gap between agriculture and non-agricultural sectors can be accounted for almost entirely by differences in sectoral returns to human capital. They argue that this finding contradicts the hypothesis advanced by many studies (see Gollin et al. (2014), Caselli (2005), Restuccia et al. (2008), Vollrath (2009), and McMillan and Rodrik (2011)) that productivity differences between sectors can be explained by frictions that cause sectoral allocation of labor to be inefficient. We use a similar approach to first establish that inefficient allocation of labor also cannot explain the wage gap between manufacturing and services in India, *given* the skill-composition of the workforce. However, we go further to show that this skill-composition is inefficient due to frictions that exacerbate the cost of acquiring human capital.

Although the literature on structural change is vast,[2] surprisingly few studies examine how frictions in human capital accumulation process impact structural transformation.[3] Caselli and Coleman (2001) develop a model to show that regional convergence of incomes associated with structural change can be explained by declining costs of acquiring human capital. Ferreira et al. (2014) develop a similar model to examine the role of education policies and resulting human capital investment choices in explaining the contrasting structural change experiences of Brazil and Korea. Our contribution here is to show, both empirically and theoretically, that lack of access to quality education and costly schooling can significantly impact structural transformation.

We make two significant contributions in the Indian context. First, we provide a novel explanation for why services are flourishing while manufacturing has stagnated in India. While low access to education has received attention in policy circles and popular press, we are unaware of any previous scholarly work that ties it to structural change in India. Most of the previous explanations[4] rely on some frictions preventing the optimal allocation of labor between sectors. We rule out the possibility of inefficient allocation of labor so that any frictions that might exist

[2]Matsuyama (2008) and Herrendorf et al. (2013) provide comprehensive reviews of this vast literature.

[3]A large literature examines, however, the role of human capital accumulation and allocation to study cross-country income differences. See, for example, Bils and Klenow (2000), Caselli (2004), and Erosa et al. (2010).

[4]These include pro-labor laws, lack of access to credit (Oura (2008), Banerjee and Duflo, 2008; Nagaraj, 2002; McKinsey Global Institute, 2006, hysteresis (Kochhar et al. (2006)), product market regulations (Alfaro and Chari (2014)), and poor infrastructure.

are not important quantitatively.

Second, we show that costs created by pro-labor regulations, that have been blamed widely for the stagnant manufacturing sector (see, for example, Aghion et. al. (2008), Besley and Burgess (2004), Hasan and Jandoc (2012), among others), are more than offset by the excess supply of labor. Moreover, these laws, also apply to services. Thus, while they may explain low productivity in manufacturing, they cannot explain why services that are also regulated by the same laws, are thriving in terms of productivity.[5]

While a large number of studies have examined the causes behind the sluggish growth of Indian manufacturing, there is little previous work seeking to explain why services have grown so fast in comparison,[6] even though they operate in a similar environment as manufacturing firms. Gupta (2008), Dehejia and Panagariya (2012), and Ho (2011, 2012) are noteworthy exceptions. Gupta (2008) argues that pro-labor laws combined with input quota regulations reduced productivity growth considerably more in manufacturing than in services. Dehejia and Panagariya (2012) attribute the spectacular growth in services to input demand from a growing manufacturing sector. Ho (2011, 2012) shows that trade liberalization interacts with size dependent policies and labor market distortions in India to affect manufacturing firms more adversely. We add to this body of work by showing that factors relating to human capital and labor supply also affect the two sectors differently.

A few growth accounting studies find that India's TFP growth is driven mainly by services (see Bosworth, Collins, and Virmani (2007), Bosworth and Collins (2008), and Verma(2012)). This paper complements these studies by examining why services have driven India's growth.

The rest of the paper is organized as follows. In section 2, we describe our data sources. Section 3 documents key stylized facts. In section 4, we present a model to formalize our hypothesis and quantify the role of frictions in human capital accumulation in India's structural change (work in progress). Section 5 concludes.

2 Data

Firm level data: Data on Indian firms are taken from the Prowess database provided by the Centre for Monitoring the Indian Economy (CMIE).[7] These data include longitudinal financial

[5]A few studies also argue that manufacturing productivity growth has increased in recent years and attribute it to reforms and growth in services that provide inputs for manufacturing activities or increase consumers' incomes, and hence demand, for manufactured goods (see Arnold et al. (2015), Bollard, Klenow, and Sharma (2013), Banga and Goldar (2004), and Chakraborty and Nunnenkamp (2008)). Fernandes and Pakes (2008) and Hasan, Mitra, and Ramaswamy (2007) also show that labor and size regulations have skewed Indian manufacturing towards more skill and capital intensive industries.

[6]Eichengreen and Gupta (2011) and Gordon and Gupta (2004) provide a comprehensive overview of the evolution of the service sector.

[7]Another source of data on both manufacturing and service firms is the Economic Census of India. However, the Census is conducted irregularly, and would allow us to examine these

information (sourced mainly from publicly available profit and loss accounts and balance sheets) on public listed, public unlisted, government owned and privately held firms over the period 1991-2010.[8]

Several aspects about the coverage of firms need mention. First, the main determinant for firms to be included in the database in any given year is availability of information about them. Hence, while most active publicly listed firms are covered, the data include only a subset of public unlisted and privately held firms as the latter are either not required to provide their financial statements, or not in as much detail as the listed firms. Coverage of firms in Prowess has improved over time, however. Second, inclusion on the basis of information availability also means that firms may stop appearing in the database even if they continue to operate, and may enter the database a few years after they began operation. Similarly, Prowess may drop coverage of a firm for a year or more and then resume it again when information becomes available. Third, these data do not cover informal firms since there is little information on these in public records.

Thus, as of 2008-09, Prowess covered around 3% of all registered firms in India, according to a CMIE report. Nonetheless, the data account for a substantial portion of business activity in India. The total income of firms in the database accounts for 84% of India's GDP, indicating that several very small firms are omitted from the data.[9]. These firms also account for 47% of the total output of non-agricultural and non-government services sector, 55% of India's exports, 70% of imports, and 58% of all corporate taxes and nearly all excise taxes collected by the government. Also, the manufacturing firms in the data constitute 79% of the total output of registered manufacturing firms in the country.

All analysis using these data is done using three alternative samples - the full sample of of public (listed and unlisted) and private firms, a "true entry" sample, and a "fuzzy entry" sample. In the full sample, we include all firms that appear in the database in any given year. In the "true entry" sample, we follow Alfaro and Chari (2014) to identify firm entry and include only those firms that appear in the database in the same year as their year of incorporation. In the "fuzzy entry" sample, we include firms that appear in the database at most five years after their year of incorporation. All three samples, therefore, are unbalanced panels.[10] Below, we present results using the full sample. Results from the other two samples are similar and

sectors only for four years across the last three decades. Several previous studies have used data from the Annual Survey of Industries but it does not have information on service sector firms.

[8]The database also includes a small number of non-profit companies or cooperatives that we exclude from our analysis. The data are available 1989 onward. But for the first couple of years, very few firms are included. The financial data for firms are reported for the financial year. In the paper, we refer to calendar years instead of financial years. So, for instance, we refer to financial year 1991-92 as 1991.

[9]It is widely believed that over half of all the registered firms in India exist only on paper (CMIE report, 2009).

[10]Using a balanced panel yields only about 650 (large) firms in the sample.

are available upon request.

We drop firms with real sales in the top and bottom 1 percent for each year. In our final full sample, we have 17,929 firms as of year 2010, of which 14,995 are public and 2,934 are private.[11] All nominal values are deflated using the consumer price index for industrial workers (2001=100) available from the Reserve Bank of India.

Household level data: We use data from employment and unemployment rounds of the National Sample Survey - a nationally representative survey conducted approximately every five years. We use data from six rounds over the period 1983-2010. Following Katz and Murphy (1992), we create separate wage and employment samples. The wage sample consists of all individuals between the ages of 15 and 65 years who had some degree of continuous attachment to the labor force - either working or unemployed[12] in the previous year and were engaged in wage employment in the reference week (since wages are only available in the reference week).[13] The employment sample consists of all persons between the ages of 15 and 65 years who worked during the previous year, or in the reference week, including self employed. This gives a close measure of the aggregate labor supply in the economy in each year.

The survey asks people to report up to four different economic activities that they were involved in during the reference week. Hence, some persons in the wage and employment samples may appear more than once under different jobs. We give each job held by such people a weight equal to the inverse of the number of jobs that the person reports to have held during the reference week. This procedure ensures that all people in the wage and employment samples receive an equal weight. Wage data are not top or bottom coded. To remove outliers, we drop the top and bottom 1% of the wage sample in each year. Wages are reported for each wage and salaried activity engaged in during the reference week.[14] No information is available on hours of work. We deflate wages by national consumer price index available separately for urban and

[11] Since early 2000s, the proportion of public unlisted and private firms has increased substantially in the data.

[12] We include those who were working or unemployed in their "principal or subsidiary capacities. Principal activity refers to the activity that a person was engaged in for the longest duration of time during the previous year. Subsidiary activity is the activity engaged in for the next longest duration of time.

[13] We don't include self employed individuals in the wage sample since no wage or income measure is available for them. Around 32% of the sample is constituted by self-employed individuals.

[14] In 1983 and 1988, about 6% and 45% of the persons in the wage sample reported zero wages. Thus, considerably more than a total of 2% of the sample was dropped in these two years. In both years, these individuals are disproportionately uneducated (about 60%), males (more than 80%), living in rural areas (around 91%), and predominantly engaged in the primary sector (nearly 55%) or as domestic helps (close to 18%). In later years, individuals who reported zero wages share similar demographic characteristics. It is not clear, however, why they constitute such a large proportion of the sample interviewed in 1983 and 1988 and comparatively negligible proportions (less than 2%) in later years of the survey.

rural areas (1983=100).

The survey reports the highest level of education completed by an individual. Using this information, we divide all people in the sample into five education categories: uneducated (this includes individuals who are illiterate, or literate without formal schooling, or those who did not complete primary education), primary educated (typically 5 years of schooling), middle schooled (typically 8 years of schooling), high school graduates (typically 12 years of schooling), and college graduates and above (typically 15 or 16 years of education, depending on the degree).

3 Stylized Facts

We present stylized facts comparing characteristics of manufacturing and service firms and workforce.

Fact 1: Average wages are higher in services than manufacturing and the wage-gap is growing over time.

Table 1 shows average real wages (in 1983 Rupees) for workers employed in manufacturing and services for all the years that the data are available for. We observe that throughout the time period, the average wage in services is higher than in manufacturing. Moreover, this gap increases over time; while in 1983, the average wage in services was 32% higher than that in manufacturing, this difference increased to 72% by 2005.

Table 1: Average Real Weekly Wages

Year	Manufacturing	Services	Percentage Difference
1983	67.61	89.29	32.07
1988	90.53	119.22	31.69
1994	117.13	175.31	49.67
2000	125.70	196.30	56.17
2005	134.89	232.47	72.34

Fact 2: Services employ a higher proportion of college and high school graduates than manufacturing.

Table 2 shows sectoral percentages of workers in various education groups for the beginning and last years for which the data are available. It is clear that services tend to employ more educated workers than manufacturing. For example, in 2005, only 7% of workers employed in manufacturing were college educated compared to 21% in services. We also observe, however, both sectors have witnessed educational upgrading over time.

Table 2: Educational Composition of Employment

Education	1983		2005	
	Manufacturing	Services	Manufacturing	Services
		(Percentages)		
No School	55.97	37.99	41.64	25.26
Primary	18.71	15.36	17.61	12.24
Middle	12.95	15.95	19.67	17.66
High School	9.44	20.25	13.79	23.67
College	2.93	10.44	7.28	21.18

Fact 3: Difference in sectoral returns to human capital account for majority of the difference in wages.

We use the textbook Mincer regression to examine whether the higher wages in services (fact 1) is merely a result of higher educational composition of its workforce (fact 2) or if it reflects higher returns to the same education levels, compared to manufacturing. Preliminary results show that the residual wage gap from sectoral Mincer regressions can almost entirely be explained by higher sectoral returns to human capital. This is work in progress. Details will be included in our next draft.

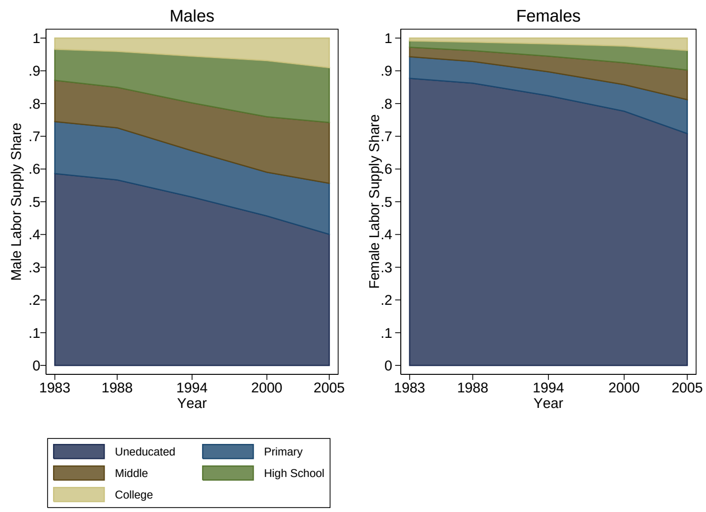
Fact 4: Educational attainment of the labor force continues to be low.

Facts 1, 2, and 3 establish that the large and growing productivity and wage gaps between the two sectors are not a result of barriers to reallocation of labor. Instead, they may reflect technology differences or worker sorting so that sectoral returns are higher in services for the same education levels. We expect, therefore, for households to respond to these higher returns by acquiring more human capital so as to successfully transition into services. However, we see in Figure 4 that the aggregate labor force continues to be largely uneducated, although there has been a slow increase in education levels over time. Comparing this figure to Table 2, we can see that supply of skills lags behind demand.

Fact 5: Labor is effectively subsidized for firms so that workers get wages below their marginal products.

We use the accounting framework presented in Appendix A to measure labor distortions. We denote expenditure on labor for firm i in sector $j =$ services or manufacturing by wl_{ji} and measure it using firm level wage bills. The value of the stock of plant, machinery, computers, and electrical equipment net of depreciation is our measure of capital. Setting the rental rate on capital as 0.10, we get firms' expenditure on capital (Rk_{ji}). We use sales as the measure of the value of output of the firm ($P_{ji}Y_{ji}$). Share of labor $(1 - \alpha_j)$ is measured as wage-bill relative to sales, averaged over all firms in sector j and the share of capital (α_j) is measured as

Figure 4: Educational Composition of Labor Force



one minus the average of share of labor in that sector.

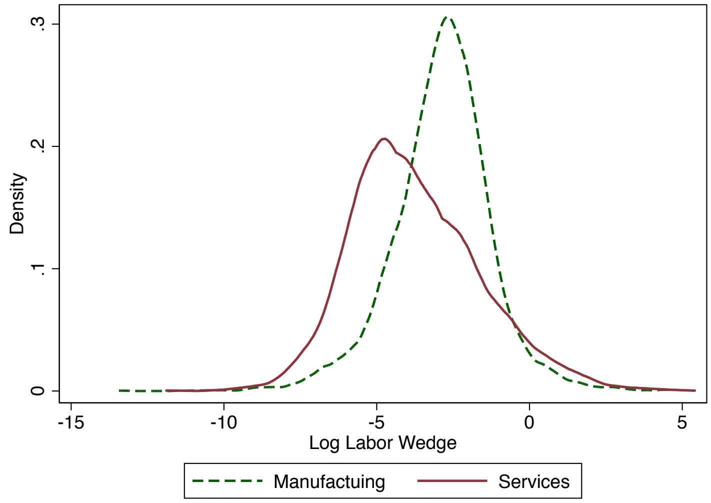
The labor wedge is $1 + \tau^l_{ji}$. If $1 + \tau^l_{ji} < 1$, that indicates that the firm is offering wages below the marginal product of labor and if $1 + \tau^l_{ji} > 1$, the firm offers wages above it. Thus, if $ln(1 + \tau^l_{ji}) < 0$, the firm offers wages below and if $ln(1 + \tau^l_{ji}) > 0$, the firm offers wages above the marginal product of labor. In the former case, labor is effectively subsidized for firms. In the latter case, labor is taxed. Figure 5 plots the distribution of the log of labor wedge as measured for firms in both sectors for the year 2010. We see that in both sectors, most firms are hiring effectively subsidized labor. A larger mass of service firms hire labor at very low wages, but a larger proportion of manufacturing firms offer wages slightly below the marginal product. A small proportion of service and manufacturing firms, however, also pay wages above the marginal product of labor.

Effective labor subsidies for both service and manufacturing firms suggest that firms face an excess supply of labor. This is consistent with facts 2 and 4 above that show that the educational composition of employment in the two sectors is skewed more towards higher education groups than that of the aggregate labor supply. Clearly, the skills supply has not kept up with skill demand.

4 Model

We develop a model that builds on the framework suggested by Eeckhout and Kircher (2012). This is work in progress and will be included in our next draft.

Figure 5: Sectoral Distributions of Labor Wedge



5 Conclusion

We document that employment in India continues to increase faster in manufacturing, even as relative productivity and wages are higher and growing in services. Several facts documented using firm and household level data rule out a major role for any barriers to reallocation of labor across sectors. Instead, data point to a large labor supply whose skills remain low even though there is a growing demand for higher skill levels. This suggests high costs of acquiring human capital in India. We are currently working on developing a model to quantify the extent to which frictions in human capital accumulation can explain India's atypical path to structural change.

Our findings have significant policy implications. There has been considerable worry expressed by policy makers about India's stagnant manufacturing sector and the inability of the fast growing services sector to absorb more workers. Our results suggest that while attempts should be made to increase the availability of less skill-intensive jobs, it would be rewarding in the long run to focus on increasing access to education and vocational skills.

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Appendix

A Accounting Framework

A.1 Setup

In this section, we present our accounting framework that we take to the data to measure and compare the degree of misallocation in the manufacturing and services sectors. The economy consists of two sectors: services, with aggregate output Y_s, and manufacturing, with aggregate output Y_m. Let the total output in the economy be:

$$Y = Y_s^{\theta} Y_m^{1-\theta} \tag{A.1}$$

Each sector consists of firms and the sectoral output is a CES aggregate of the differentiated products of these monopolistically competitive firms:

$$Y_j = \left[\sum_{i=1}^{N_j} Y_{ji}^{\sigma} \right]^{\frac{1}{\sigma}} \tag{A.2}$$

where $j = s, m$, $i = 1, ..., N_j$ denotes firms, and N_j is the total number of firms in sector j.

Firms produce output using capital, k, and labor, l, and the following production function:

$$Y_{ji} = A_{ji} k_{ji}^{\alpha_j} l_{ji}^{1-\alpha_j} \tag{A.3}$$

Assume Y to be the numeraire good, so that its price, $P = 1$. Let the sectoral output prices be P_s and P_m, and firm product prices be P_{ji} for $i = 1, ..., N_j$ and $j = s, m$.

Optimization problem for the sector:

$$\underset{Y_{ji}}{Max} = P_j Y_j - P_{ji} Y_{ji}$$

subject to the sectoral aggregate output function, given by equation A.3.2. This yields the following first order condition:

$$P_{ji} = P_j Y_j^{1-\sigma} Y_{ji}^{\sigma-1} \tag{A.4}$$

Figure 6 shows that service firms have a higher share of labor (wage bill divided by the value of sales) than manufacturing firms. Service firms' mean share of labor has increased over the sample period, especially between 1995 and 2005 and has settled close to 22%. In contrast, the average share of labor in manufacturing firms has stayed roughly constant around 10%. In both sectors, the median labor share lies below the mean but its trend over time has been similar to the mean.[15]

[15]The data only provide information on wage bills. We cannot separately identify wages and

Figure 6: Average Labor Shares in Services and Manufacturing

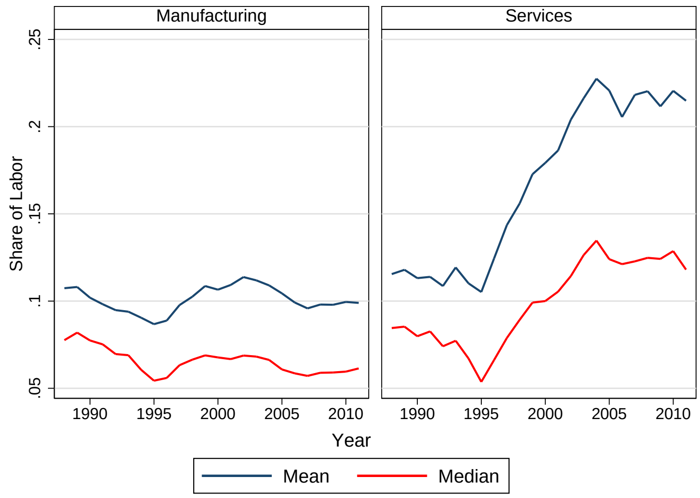

Figure 7: Size Distribution of Service and Manufacturing Firms

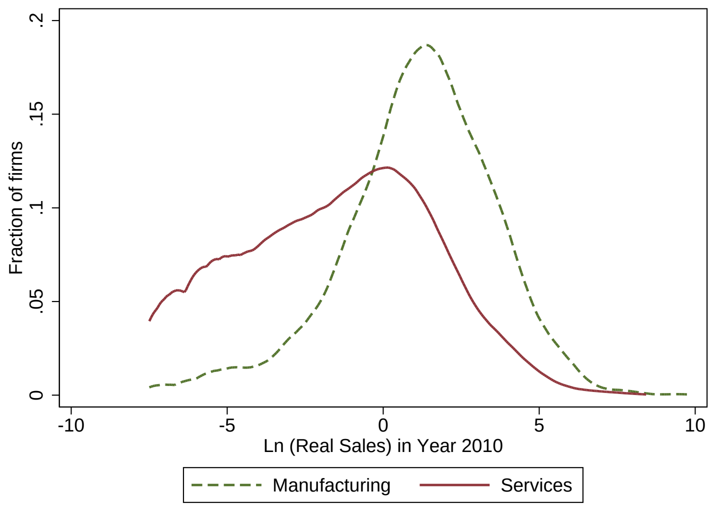

Figure 7 plots the distribution of log sales[16] in the two sectors in 2010. We observe that service firms operate at a smaller scale (value of sales) than manufacturing firms. There is a significantly larger (smaller) mass of small (large) service firms than manufacturing firms.

Firms face policy distortions in their operations. We focus on two distortions by introducing wedges on output and labor (τ_{ji}^{Y} and τ_{ji}^{l}, respectively). Both service and manufacturing firms operate in a similar economic environment, particularly in terms of credit, infrastructure, and

number of employees or hours worked.

[16] Log sales of zero indicate Rupees 1 million in real terms.

labor regulations. However, since service firms operate at a smaller scale (Figure A.2) and labor regulations in India are often size dependent, and because they may be less dependent on external finance (Buera, Kaboski, and Shin (2013)) and infrastructure, they may be less severely impacted by such constraints. We can capture this potentially asymmetric effect of credit constraints, infrastructural bottlenecks and size dependent regulations by including an output wedge. Also, while the labor laws are similar for firms in the two sectors, service firms have a higher share of labor, on average (Figure A.1). This may again entail an asymmetric effect of labor regulations on the two sectors. We capture this using a labor wedge. As explained by Hsieh and Klenow (2009), including a wedge on labor also captures distortion on capital input as what matters is their relative marginal products.

The profit maximization problem faced by firms is:

$$\underset{l_{ji},kji}{Max} \pi_{ji} = (1-\tau^Y_{ji})P_{ji}Y_{ji} - w(1+\tau^l_{ji})l_{ji} - rk_{ji}$$

subject to the production function in equation A.3.3 and where w represents labor wage and r represents the rental rate on capital.

This yields the following two first order conditions:

$$w(1+\tau^l_{ji}) = (1-\alpha_j)(1-\tau ji^Y)P_{ji}A_{ji}k^{\alpha_j}_{ji}l^{-\alpha_j}_{ji} \tag{A.5}$$

$$r = \alpha_j(1-\tau ji^Y)P_{ji}A_{ji}k^{\alpha_j-1}_{ji}l^{1-\alpha_j}_{ji} \tag{A.6}$$

Dividing the first FOC by the second, we get:

$$(1+\tau^l_{ji}) = \frac{1-\alpha_j}{\alpha_j}\frac{rk_{ji}}{wl_{ji}} \tag{A.7}$$

Using the production function for firms (equation (A.3.3)) and rearranging the second FOC, we get:

$$(1-\tau^Y_{ji}) = \frac{1}{\alpha_j}\frac{Rk_{ji}}{P_{ji}Y_{ji}} \tag{A.8}$$

These last two equations identify the labor and scale wedges.