Can Total Factor Productivity Explain Value Added Growth in Services?

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Abstract: This paper accounts for the rapid growth of the service sector observed in India for the 1980-2005 period. A sectoral growth accounting exercise shows that total factor productivity (TFP) growth was the fastest for services; moreover this TFP increase was significant in accounting for the service sector value added growth. A growth model with agriculture, industry and services as three principal sectors is carefully calibrated to Indian data using sectoral TFP growth rates as primary inputs. The model performs well in accounting for the evolution of value added shares and the growth rates of these shares from 1980-2005. The performance of the model improves significantly when the post 1991 increase in service sector TFP growth is accounted for. It is argued that market-based liberalization policies directed towards deregulation and privatization of business and communication services explain the growth of TFP and hence of output in the Indian service sector.
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1 Introduction

An empirical comparison of the historical growth experiences of contemporary developed countries with the current growth experiences of some fast growing contemporary developing nations reveals some significant differences in their growth patterns. For most industrialized nations, such as United Kingdom, France and the United States, historical data show that at low levels of per capita income, the agricultural sector dominated the composition of output and employment. As these nations embarked on a path of rapid and sustained economic growth, resources were transferred from the agricultural sector to the manufacturing and service sectors. Only when the economy matured and reached the status of a high-income nation did the role of the service sector become more dominant. Today, for some low income, rapid growing industrializing nations, this process of sectoral reallocation of economic activity, also known as structural transformation or structural change, looks different. In these countries, even at low levels of per capita income, the service sector accounts for a significant amount of the economy's output as measured by its share in Gross Domestic Product (GDP). Moreover, in these economies the share of services in GDP has been increasing at a rapid rate, much greater than the corresponding growth rate witnessed by the service sector in the GDP of contemporary developed economies when they were at equivalent stages of development. In some of the low-income economies in the present day, the role of the service sector has become more prominent at relatively early stages of economic development. This paper accounts for the rapid growth of the service sector in one of today's low-income, fast growing, developing economies- India, and investigates the factors driving this services-led growth in the economy.

Figure 1 presents an empirical comparison of the current growth experience of India with the historical growth experience of the United States (U.S.). During the 1980-2005 period, the average annual growth rate of real output of the aggregate Indian economy was 5.8 percent while the growth rate of real output produced in the service sector exceeded the aggregate growth rate, measuring 7.2 percent. In other words, the service sector's share in GDP grew at an average annual rate of 1.3 percent for the 1980-2005 period. This growth rate is much higher than the corresponding growth rate witnessed by the U.S. economy, when the U.S. was at an equivalent stage of development, where the stage of development is measured by the relative level of real GDP per capita. The upper panel of Figure 1 shows

the growth in the share of service's output in Indian GDP during the 1980-2005 period. One can also see how the relative Indian/U.S. GDP per capita evolved during the same period. From this figure, it is evident that in 1980, when India's GDP per capita was 5.2 percent of the U.S. GDP per capita, the share of services in Indian GDP was about 38 percent. By 2002, Indian GDP per capita had grown to 7.2 percent of U.S. GDP per capita, at which date the share of services in Indian GDP was 49 percent. By the end of the sample period in 2005, Indian GDP per capita had increased to about 8.3 percent of U.S. GDP per capita, and the corresponding share of services accounted for about 52 percent of Indian GDP.

The lower panel depicts how the share of services in U.S. GDP [1] evolved during the period 1839-1899. In 1839, the U.S. GDP per capita relative to its average 1980-2005 value was similar in magnitude to the 1980 Indian/U.S. GDP per capita ratio. In other words, in 1839 the U.S. GDP per capita was 5.3 percent of the average U.S. GDP per capita of 1980-2005, and services accounted for 38 percent of aggregate GDP. In 1859, the U.S. had grown to 7.3 percent of its average 1980-2005 GDP per capita value with the output share of services being 41 percent. By 1899, U.S. GDP per capita had grown to 13.5 percent of its average 1980-2005 GDP per capita value, and the output share of services in GDP had risen only to about 47 percent. One can infer from these numbers that the share of service's output in U.S. GDP grew at an average annual rate of 0.36 percent during the 1839-1899 period. In comparison, the average annual growth rate of the output share of services in Indian GDP during the 1980-2005 period was one full percentage point higher than its U.S. counterpart when the U.S. was at an equivalent stage of development.

The objective of this paper is to explain the rapid growth of value added in the service sector in India and to examine the factors driving this services-led growth in the economy for the period 1980-2005. With this objective in mind, I develop a three-sector general equilibrium model consisting of agriculture, industry and services. Output in each sector is produced using capital, labor and land (in agriculture). The production function in each sector is assumed to be a Cobb-Douglas and I allow for different values of capital and labor shares, as well as different growth rates of total factor productivity (TFP) across the sectors. There is a representative agent which has homothetic preferences defined over goods of the three sectors. Using sectoral data, I calculate sector specific TFP growth rates which are fed exogenously into the model with the objective of examining the model's performance

[1] These data are obtained from Weiss and Gallman (1969); they report data for every ten years starting from 1839 to 1899.

with respect to the evolution of sectoral value added shares over the 25-year period. The results indicate that the model can closely track the time paths and also match the growth of sectoral value added shares for the sample period. Using this as a baseline model, I conduct a quantitative experiment to highlight the importance of increase in service sector TFP during the 1991-2005 period. The results of this exercise reveal that the performance of the model improves significantly when the post-1991 increase in service sector TFP growth is accounted for. I argue that following economic liberalization in 1991, it was the inception of market-based liberalization policies in services which resulted in significant productivity improvement in this sector.

The model is closest in spirit to Acemoglu and Guerrieri (2008), as it uses a combination of differences in factor intensities and differential exogenous TFP growth across sectors to generate non-balanced growth and structural change across sectors. If I allow for factor intensities to be equal across sectors and assume away the presence of a fixed factor, the model collapses to Ngai and Pissarides (2007). The main contribution of my work is empirical: I use sectoral data to calibrate factor shares and measure TFP growth rates. Using these differential productivity growth rates as primary inputs, I am able to explain the source of value added increase in Indian services, which becomes more significant after economic liberalization in 1991.

The limitation of the model is seen in it's predictions of the employment levels in the three sectors. While the direction of the trends of sectoral employment are captured well by the model, a simple exercise tries to correct for the model's failure to replicate the level of the employment shares. Specifically, in section 10, one of the assumptions of the baseline model- equal wages across sectors- is relaxed. Here, by allowing for wages in the industrial and service sectors to be higher than in agriculture, I find that the model's fit of sectoral employment shares to the data for the given period improves significantly.

The next section elaborates on an empirical exercise conducted to identify a broader set of low income, fast growing, service driven economies. This exercise highlights why I choose India and calibrate the model using Indian data. Among 42 countries identified by the World Bank as being low-income in 1980, 11 witnessed annual average growth rates of GDP per capita in excess of 2 percent during 1980 to 2004 and substantial reductions in the size of their agricultural sector. Of these fast growing, low income countries, I find that four of them experienced GDP growth dominated by growth of value added in the service sector,

rather than by growth in the industrial sector as typifies historical evidence on structural transformation from industrialized countries. India serves as a strong representative of this services-led growth group.

The rest of the paper is organized as follows: the next section conducts the empirical exercise described in the previous paragraph. Section 3 contains the empirical facts about sectoral output and sectoral employment in the Indian economy. The growth accounting exercise is explained in section 4. Sections 5, 6 and 7 discuss the model, the calibration procedure and the results, respectively. The experiment conducted to assess the effect of increased TFP growth following economic liberalization in 1991 is described in section 8. Section 9 presents the different hypotheses offered to account for the rapid growth in the share of service's output in the Indian economy. Section 10 discusses a version of the model in which the assumption of equal wages is relaxed. The last section concludes.

2 Identifying Services-led Growth

In this section, I conduct an empirical exercise to identify the set of low-income, rapid growing, economies which exhibit the pattern of services-led growth. A low-income country is defined as a country with a GDP per capita less than 825 real US dollars in 1980[2]. Following this criterion, I identify 42 low-income countries in 1980 and calculate their average growth rates of GDP per capita during the period 1980-2004. Table 10 lists these countries in order of descending growth rates, together with their respective GDP per capita in 1980. The average growth rate for the entire sample is 0.51 percent, owing to a large number of countries which witnessed negative growth rates during this time period. Amongst these countries, 17 countries experienced negative growth rates, while 11 countries grew at an average rate of 0-1 percent and three countries witnessed growth rates between 1-2 percent. My interest lies in choosing the rapidly growing countries which witnessed average annual growth rates of GDP per capita in excess of 2 percent which was the secular growth rate of the U.S. economy in the twentieth century[3]. The U.S. economy was the industrial leader throughout the twentieth century, and hence the growth performance of the rapid growers is measured relative to the U.S. economy. I call these 11 countries *Rapid Growers*. These

[2]In 2004, The World Bank defined a low-income country as a country which had a level of Gross National Income per capita less than 825 real US dollars.

[3]Following Kehoe and Prescott (2002); they calculate the average growth rate of output per working-age person in the U.S. economy to be 2 percent in the twentieth century.

countries include China, Thailand, Bhutan, India, Indonesia, Sri Lanka, Chad, Lesotho, Pakistan, Bangladesh and Nepal.

Next, I examine the performance of the three sectors, agriculture, industry and services, in contributing to aggregate growth of output in these economies. It is well recognized that as an economy grows and witnesses structural transformation, growth proceeds at an uneven rate from sector to sector. Following Syrquin (1988), I examine the relation between aggregate and sectoral growth by differentiating with respect to time the definition of aggregate output, $V = \sum V_i$ and expressing the result in growth terms:

$$g_V = \sum_i \rho_i g_{V_i}$$

where g_V and g_{V_i} are the growth rates of V and V_i at date t, respectively, and the weights are sectoral output shares at date t, $\rho_i = V_i/V$. The above equation expresses the contribution of each sector to aggregate GDP growth measured in terms of the average share of total GDP accounted by this sector, weighted by the growth rate of GDP in this sector.

For each of the 11 Rapid Growers, I decompose the growth rate of aggregate GDP using growth rates of sectoral value added and shares of the sectoral value added in GDP. Following this decomposition, I identify those low income, fast growing, countries which have witnessed service-sector driven growth. Specifically, in these economies, the service sector has made the highest average contribution to aggregate growth during the 1980-2004 period. I call them *service sector* dominated countries. This set of countries includes India, Sri Lanka, Pakistan and Bangladesh. Amongst all these service-sector led countries, India witnessed the most rapid growth in GDP and in GDP per capita during the sample period.

3 Sectoral Data Facts

During the 1980-2005 period, real value added in agriculture, industry and services grew at an average annual rate of 3.2, 6.2 and 7.2 percent, respectively. Figure 2 depicts the evolution of the shares of value added in agriculture, industry and services during the 1980-2005 period for India. Between 1980 and 2005, the share of value added in agriculture declined from 38 percent to about 21 percent, the share of industry increased from 24 to 27 percent, while the share of services grew from 38 percent to 52 percent. It is evident that the decline in agriculture's share of value added has been mirrored in an increase in service's share of value added, while industry's share of value added has increased only modestly over

the time period. In terms of shares in aggregate value added, the share of agriculture declined at an average annual rate of 2.2 percent over the 1980-2005 period. During the same period, the share of services in Indian GDP grew at 1.3 percent per year, while industry's share in GDP showed a small increase of 0.3 percent per year. This differential between the growth rates of shares of industrial and service's value added becomes sharper after 1991. For the 1991-2005 period, share of industry's value added showed no growth at all while the share of service's value added grew at a rate of 1.7 percent per annum. The share of agriculture's value added was declining in both the sub-periods, at an average annual rate of 1.7 percent during 1980-1990 and at 2.8 percent during the 1991-2005 period.

While the value added data show significant growth in the share of services in aggregate output, the share of employment in this sector is relatively small[4]. This observation where services account for a significant share in aggregate output, but a relatively smaller share in aggregate employment has been termed as 'jobless' growth in services (Bhattacharya and Sakthivel (2004), Banga (2006)). The trends in the share of employment in services and in the other two sectors are presented in figure 3.

The sectoral employment graph reveals that reallocation of employment out of agriculture and into industry and services has been slow. Even by 2005, the share of employment in agriculture was still high, at 52 percent, whereas in industry and services, it was 19 and 29 percent, respectively. Clearly, the shares of sectoral employment are very different from the shares of sectoral value added. Some authors have tried to rationalize the slow movement of labor from agriculture into industry and services in India. Panagariya (2006) discusses how the growth of unskilled labor in the organized sector has been slow due to stringent labor regulations. He argues that the formal sector in India has witnessed increasing wages and has a lot of potential to absorb unskilled labor. In India, employment in the informal sector has been rising. However, since the wage differential between the non-agricultural informal sectors and the agricultural sector (which is predominantly informal in nature) is not very large, there does not exist a big enough incentive for labor to move out of agriculture and into industry and services. Moreover, inter-state migration has been extremely slow in India due to linguistic differences and lack of social protections such as mutual insurance provided to members of the same sub-caste networks, making it dangerous to travel outside the reach of one's social network (Munshi and Rosenzweig (2004)). Additionally, Banerjee

[4]Detailed description of the output and employment data are provided in section 3.

(2006) discusses how the lack of cheap urban housing and poor planning in urban areas has served as a barrier to migration. Since most of the industrial and service firms are located in urban areas in India, the slow rural-urban migration has some merit in explaining the slow movement of labor across the sectors.

In sum, India's structural transformation is characterized by fast reallocation of value added shares, but a much slower reallocation of employment, across the three sectors.

4 Growth Accounting

4.1 Methodology

To gain further insight into the sources of growth in service sector value added, I conduct a growth accounting exercise for each of the sectors - agriculture, industry and services- for the 1980-2005 period. This exercise involves decomposing changes in gross output by sector into the portions due to changes in factor inputs and the portion due to the changes in efficiency with which these factors are used, measured as the TFP of a sector. The first year for which sectoral gross output data is available for India is 2000. Since my sample period ends in 2005, it would be difficult to draw any inferences about productivity growth for the entire sample period using sectoral gross output data for 2000 to 2005. Instead, I use data on value added by sector which are strongly correlated to gross output by sector[5].

The production function in each sector is assumed to be Cobb-Douglas with constant returns to scale. In particular, the function is described by

$$Y_{jt} = A_{jt} K_{jt}^{\nu_j} N_{jt}^{1-\nu_j} \qquad j \in \{industry(i), services(s)\}$$

where Y_j, K_j, N_j and A_j are the output, capital stock, labor and TFP in sector $j = \{i, s\}$ respectively. ν_j and $1-\nu_j$ represent the share of rental payments to capital and share of wage payments to labor in the total income of sector $j = \{i, s\}$ respectively. The methodology of constructing factor shares is described below. Then the growth rate of the total factor

[5]The correlation for each of the sectors is about +0.99.

For the three sectors, using gross output data and a Cobb-Douglas production function with numerical values of factor shares as described here, and the share of intermediate inputs in gross output being calibrated from input-output tables, I find that average annual growth of TFP in agriculture, industry and services was 0.5%, 0.6%&1.4%, respectively during 2000-2005.

productivity growth in sector $j = \{i, s\}$ can be estimated as

$$\frac{dA_j/dt}{A_j} = \frac{dY_j/dt}{Y_j} - \nu_j \frac{dK_j/dt}{K_j} - (1 - \nu_j)\frac{dN_j/dt}{N_j} \tag{1}$$

The agricultural production function has an additional input of land (L_a). The production function is accordingly modified as

$$Y_{at} = A_{at} K_{at}^{\nu_a} L_{at}^{\gamma_a} N_{at}^{1-\nu_a-\gamma_a}$$

and therefore the growth rate is given by:

$$\frac{dA_a/dt}{A_a} = \frac{dY_a/dt}{Y_a} - \nu_a \frac{dK_a/dt}{K_a} - (1 - \nu_a - \gamma_a)\frac{dN_a/dt}{N_a} - \gamma_a \frac{dL_a/dt}{L_a} \tag{2}$$

where ν_a, γ_a, $(1 - \nu_a - \gamma_a)$ are the shares of capital income, rental income from land and labor income respectively.

4.2 Data

In order to conduct growth accounting, data are collected for the three sectors for the 1980-2005 period.

Real GDP: Data for sectoral real GDP are taken from the Central Statistical Organisation (CSO) of India. Agriculture includes agriculture (proper), forestry, logging and fishing; Industry consists of manufacturing, mining, electricity, gas and water supply, and construction, while Services include trade, hotel, transport, communication, finance, insurance, real estate, business services and social and personal services. All data are measured in constant 1994 Indian Rupees. The data collection methodology and definitions are in accordance with the recommendations of the 1993 System of National Accounts (1993 SNA) prepared under the auspices of the Inter Secretariat Working Group on National Accounts comprising of the European Communities(EUROSTAT), International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD), United Nations and World Bank. Details of data definitions and methodology are provided in the report by Ministry of Planning and Programme Implementation, Department of Statistics and Programme Implementation (1999)[6].

Capital Stock: The capital stock series for each of the three sectors are constructed using the Perpetual Inventory Method (PIM), where investment is measured using the gross

[6]Detailed description of methodology on how these data are constructed can be provided upon request. India reports real GDP statistics using fixed weighted indexes; no estimates of GDP using chain weighted indexes are available.

fixed capital formation series. The depreciation rate is assumed to be constant at 5 percent each year. All sectoral capital stock data are measured in constant 1994 Indian Rupees and are obtained from the CSO of India.

Employment: India does not report data on the number of labor hours worked in each sector. Hence, I measure employment as the number of people working in each sector. Sectoral employment numbers are calculated using the definition of employment on a current daily status (cds) basis [7]. These data are constructed with the help of annualized growth rates of sectoral employment reported by Gupta (2002).

Land: An estimate of land used in the agricultural sector is needed. Data series on gross sown area are used for this purpose. Gross sown area is defined as the sum of area covered by all individual crops including the area sown under crops more than once during a given year. It is also referred to as gross cropped area. These data are obtained from Business Beacon, Centre for Monitoring Indian Economy (CMIE) [8].

Factor Income Shares: I follow Gollin (2002) and calculate factor shares by adjusting for income of the self- employed. Factor income data are available from 1981-2000 period for different sub-sectors of the economy. These data comprise of Compensation of Employees (COE) and Operating Surplus (OS). In each sub-sector, the COE and OS are further divided into two components, one part accruing from the organized sector and the second part as originating in the unorganized sector. I consider OS of the unorganized sector as Operating Surplus of private unincorporated enterprises (OSPUE). Then, using the second adjustment method followed by Gollin,[9] I compute labor income shares for different sub-sectors. Using the share of each sub-sector's output in the output of the agricultural, industrial and service sectors as weights, I construct weighted labor shares for these three sectors. The share of capital income in the industrial and service sectors is deduced as a residual. The share of rental income from land in agricultural income is taken to be 0.2 (average over the period 1980-1999) as reported by Sivasubramonian (2004). Consequently, the labor and capital shares are rescaled to sum to 1 minus the share of land.

I also conduct a sensitivity analysis of the growth accounting results by using two

[7] Details of the cds approach are provided in the data appendix.

[8] Note that this is incomplete - land is also used for cattle and large animals etc. but no estimates of these data are available. Not accounting for these in land estimates probably overestimates TFP growth in agriculture.

[9] Labor income share= Compensation of Employees/(Compensation of Employees+Operating Surplus of Incorporated Enterprise+Consumption of Fixed Capital)

alternate sets of factor shares. The first set consists of sectoral labor shares computed using Global Trade Analysis Project (GTAP) data, as reported by Roe (2008). The second set assigns the standard value of one-third as the share of capital income and treats the residual as the share of labor income in the industrial and service sectors. For the agricultural sector, the capital income and labor income shares of one-third and two-thirds, are rescaled so that they sum to 1 minus the share of land, where the share of land is taken as 0.2.

4.3 Results

Table 1 reports the decomposition of average annual growth in real value added due to change in capital, labor, land and TFP in each sector. These results have been obtained using 'baseline' factor shares, calibrated as described in the previous section. I refer to these as 'baseline' results.

For the agricultural sector, the labor income share is 0.58, the share of land is 0.2 and the share of capital determined residually is 0.22. The percentage contribution of each factor is measured as the ratio of the product of the factor share with the growth rate of the factor to real value added growth rate. During the 1980-2005 period, agricultural real value added grew at an average annual rate of 3.25 percent. The contributions of capital, labor and TFP were 18, 21 and 59 percent, respectively. Land made a small contribution of about 2.5 percent during the entire period. In the pre-liberalization period, 1980-1990, real value added was growing at 4.27 percent, of which TFP growth accounted for 51 percent. Following TFP, the contribution of labor was next largest at 29 percent, followed by capital which accounted for about 16 percent. Land made a small contribution of about 3 percent. In the post-liberalization period, growth in real value added decreased to about 2.5 percent, and therefore the percentage contribution of TFP increased to account for 69 percent of real value added growth. Capital and labor accounted for 21 and 9 percent of growth, respectively, whereas the contribution of land was small at about 0.6 percent.

With respect to the industrial sector, the calibrated capital and labor shares are 0.51 and 0.49, respectively. Real value added in industry grew at 6.25 percent during the entire 1980-2005 period. The contribution of capital was the largest and measured about 53 percent. while labor was about 25 percent. TFP in industry made a smaller contribution of 21 percent during this period. In the pre-liberalization period, real value added was growing at 6.78 percent, to which capital made a significant contribution of 56 percent. The contribution

made by labor was 31 percent, followed by TFP which accounted for only 13 percent. In the post-liberalization period, 1991-2005, growth of industrial real value added slowed to 5.77 percent. Again, the contribution of capital was largest, accounting for about 52 percent, followed by labor which made a contribution of 22 percent. In this period, the contribution of TFP increased to account for about 25 percent of real value added growth in this sector.

For the service sector, the shares of capital and labor income are calculated to be 0.37 and 0.63, respectively. During the 1980-2005 period, real value added grew at 7.22 percent, of which TFP accounted for 45 percent, followed by capital and labor which accounted for about 22 and 31 percent, respectively. In the pre-liberalization period, real value added grew at 6.63 percent. The contributions of capital and labor were 19 and 39 percent, respectively, while TFP was about 40 percent. In the post-liberalization period, service sector real value added growth increased to 7.77 percent. The contribution of capital increased to 24 percent, while the contribution of labor decreased to about 25 percent in this period. TFP's contribution increased and TFP growth alone, in this period accounted for 50 percent of real value added growth.

Bosworth, Collins and Virmani (2007) conduct sectoral growth accounting for the Indian economy and find similar sectoral TFP growth rates for the 1980-2004 period. Their estimates of TFP growth rates in agriculture, industry and services are 1.1, 1 and 2.9 percent respectively. Their estimates differ slightly from mine and could be because they do not calibrate factor shares using data; instead they assume certain values for sectoral factor shares. In agriculture they use 0.5, 0.25, and 0.25 for labor, capital and land respectively. In industry and services they assume the share of capital and labor to be 0.4 and 0.6 respectively. In their accounting exercise, they have an additional factor input - human capital, as measured by schooling, in each sector. In spite of this additional input, my estimates of TFP growth rates are similar to their numbers, suggesting that education has not played a significant role in contributing to the growth of sectoral real value added[10].

From Table 1 and Figure 4 one observes that the service sector in India witnessed rapid TFP growth which exceeded TFP growth in the agricultural and industrial sectors for the 1980-2005 period, primarily because of the high growth it experienced in the 1991-2005 period. This is a striking result because, in contrast, measures of service's TFP growth are

[10]Verma (2011) incorporates sectoral human capital and finds that the TFP growth rates are not very different as those obtained here.

low in advanced economies, especially when compared to the TFP growth in the industrial sector in the data from most countries. Echevarria (1997) reports sectoral TFP growth rates for 14 OECD countries for the 1970-85 period. In all countries, measured TFP growth in services is lower than in industry. Moreover, in the Indian case the finding of high TFP growth in services does not depend on the factor shares. I report results using two other sets of factor shares in the appendix. Table 2 reports the results using the GTAP computed sectoral factor shares, and Table 3 presents the results using capital share values of one-third in the sectors. These results validate the finding that among the three sectors, TFP growth is highest in the service sector for the entire sample period, especially due to the high growth observed in the post-liberalization period.

5 Model

5.1 Technology

I develop a three-sector dynamic general equilibrium model in which an infinitely-lived representative household owns land, labor and capital and is endowed with one unit of productive time. Therefore, the model is set up in terms of per capita quantities. Time is discrete and is indexed by $t = 0, 1, ...\infty$.

There are three sectors in the economy: agriculture, industry and services. In each sector, the production function exhibits constant returns to scale and is assumed to be Cobb-Douglas in form. The agricultural good is produced using capital k_a, land l_a, and labor n_a as inputs; the industrial good and the service good are produced using capital and labor, (k_i, n_i), (k_s, n_s), respectively. θ and γ are the shares of capital and land in agricultural output, α and ϕ are the capital shares in industrial and service's output, respectively.

Firms in each sector are assumed to behave competitively. In each period, they rent capital, labor and land from the representative agent at rates, r_k, w and R_l, respectively. The firm in the agricultural sector solves

$$\max_{\{k_{at}, n_{at}, l_{at}\}} \{p_{at} y_{at} - r_{kt} k_{at} - w_t n_{at} - R_{lt} l_{at}\}$$

subject to

$$y_{at} = b_{at} k_{at}^{\theta} l_{at}^{\gamma} n_{at}^{1-\theta-\gamma}, \quad \theta + \gamma \in (0, 1) \tag{3}$$

In the industrial sector, the firm solves

$$\max_{\{k_{it},n_{it}\}} \{y_{it} - r_{kt}k_{it} - w_t n_{it}\}$$

subject to

$$y_{it} = b_{it}k_{it}^{\alpha}n_{it}^{1-\alpha}, \quad \alpha \in (0,1) \tag{4}$$

In the service sector, the firm solves

$$\max_{\{k_{st},n_{st}\}} \{p_{st}y_{st} - r_{kt}k_{st} - w_t n_{st}\}$$

subject to

$$y_{st} = b_{st}k_{st}^{\phi}n_{st}^{1-\phi}, \quad \phi \in (0,1) \tag{5}$$

where b_{jt} and p_{jt} are the levels of TFP and price respectively, in sector $j = \{a, i, s\}$. Note that $p_{it} = 1$ since the industrial good is the numeraire.

There are three market clearing conditions for produced goods:

$$c_{at} = y_{at} \tag{6}$$

$$c_{it} + k_{t+1} - (1-\delta)k_t = y_{it} \tag{7}$$

$$c_{st} = y_{st} \tag{8}$$

The market clearing conditions for agricultural and service goods imply that output produced in these sectors is consumed. The industrial good can either be consumed or it can be used for investment, where $\delta > 0$ is the constant rate of depreciation[11].

There are also three market clearing conditions for primary inputs:

$$\begin{aligned} k_{at} + k_{it} + k_{st} &= k_t \\ n_{at} + n_{it} + n_{st} &= 1 \\ l_{at} &= 1 \end{aligned}$$

where labor supply per capita and the supply of land per capita, are each normalized to unity[12].

[11] Indian investment data shows that the majority of aggregate investment takes place in the industrial sector, and that the share of industrial investment in aggregate investment has been rising, while the corresponding share in the service sector has been decreasing. Hence I abstract away from including capital formation in the service sector.

[12] In the data, stock of agricultural land is virtually fixed and increases by less than 4 percent over the 23-year time interval. In comparison, agricultural capital grows by 82 percent, and labor grows by more than 100 percent.

5.2 Preferences

There is an infinitely-lived representative household endowed with one unit of time in each period. The lifetime utility function for the household is given by

$$\sum_{t=0}^{\infty} \beta^t U(c_{at}, c_{it}, c_{st})$$

where c_j is the consumption of good j $(j = a, i, s)$ in period t and β is the discount factor. The per period utility function is given by

$$U(c_{at}, c_{it}, c_{st}) = ln(\omega_a c_{at}^{\epsilon} + \omega_i c_{it}^{\epsilon} + \omega_s c_{st}^{\epsilon})^{(1/\epsilon)}$$

with $\epsilon < 1$ and $\sum \omega_{j=a,i,s} = 1$. Thus, the elasticity of substitution between c_a, c_i and c_s is given by $\frac{1}{1-\epsilon}$.

The representative household faces the following maximization problem in each period

$$\max_{\{c_{at}, c_{it}, c_{st}, k_{t+1}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t U(c_{at}, c_{it}, c_{st})$$

subject to

$$p_{at}c_{at} + c_{it} + p_{st}c_{st} + k_{t+1} - (1-\delta)k_t = r_{kt}k_t + w_t + R_{lt} \quad \forall \ \ t = 0, 1, ..\infty$$

with k_0 given.

5.3 Competitive Equilibrium

Given k_0, an equilibrium is defined as a sequence of real prices $\{r_{kt}, R_{lt}, w_t, p_{at}, p_{st}\}_{t=0}^{\infty}$ and allocations $\{k_{at+1}, k_{it+1}, k_{st+1}, n_{at}, n_{it}, n_{st}, c_{at}, c_{it}, c_{st}, l_{at}\}_{t=0}^{\infty}$ such that

1. Given prices, the sequence $\{c_{at}, c_{it}, c_{st}, n_{at}, n_{it}, n_{st}, k_{t+1}\}_{t=0}^{\infty}$ solves the household's maximization problem;

2. Given prices, the sequence $\{k_{at}, k_{it}, k_{st}, n_{at}, n_{it}, n_{st}, l_{at}\}_{t=0}^{\infty}$ solves the firms' maximization problem;

3. The markets for primary inputs and final goods clear.

5.4 Model of Non-Balanced Growth with Structural Change

The model presented above is a three-sector growth model which depicts non-balanced growth and structural change. A brief discussion of these two characteristics follows.

The process of structural change has been studied by previous authors using two classes of models. The first class of models focus on the demand side reasons for structural change. These models use non-homotheticities in preferences and neutral technological change across sectors. The intuition is that if income elasticities of demand are not unitary, then as economies grow richer, reallocation of resources across sectors occurs due to differences in the marginal rate of substitution between goods. Examples of these models are Echevarria (1997) and Kongsamut, Rebelo and Xie (2001). The second class of models focus on the supply side reasons for structural change and emphasize that differential productivity growth across sectors can generate structural transformation even with homothetic preferences. This is done by assuming that the elasticity of substitution between goods is different from unity, and authors like Baumol (1967), Dekle and Vandenbroucke (2009), Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008) use these models. Yet others, like Rogerson (2008), use a hybrid of both classes of models: uneven technological change across sectors coupled with non-homothetic preferences. Rogerson states that while uneven technological change can generate reallocation across industry and services, non-homothetic preferences are required to generate the reallocation of resources out of agriculture.

This paper would fall into the second class of models, since it is a sectoral growth model capturing structural change using a combination of differences in factor intensities and differential TFP growth[13]. Acemoglu and Guerrieri (2008) present a two-sector growth model and explain how non-balanced growth can occur in the presence of differential capital intensities and differential TFP growth across two sectors. They calibrate the model to U.S. data and estimate a value for the elasticity of substitution parameter from the data. Their estimation results in an elasticity value lesser than one implying that the two sectors are complements. They further show that the elasticity of substitution between products will be less than one, if and only if the elasticity of substitution between labor and capital is less than one. The converse applies when elasticity of substitution is greater than one.

The elasticity of substitution parameter plays an important role in generating structural

[13]It is important to note that in India's case, the high income elasticity of demand for services (and thus use of non-homothetic preferences) is empirically implausible; I elaborate on this point in section 8.

change in models with differential TFP growth across sectors. Specifically, if consumption goods are complements, then, in the presence of differential TFP growth across sectors, resources are transferred to the sector experiencing the lowest TFP growth. But if consumption goods are substitutes, then resources move to the sector witnessing highest TFP growth. This can be explained as follows. The sector witnessing highest TFP growth also experiences the most rapid decline in the price of the good it produces. If the goods are substitutes, the household increases its share of consumption expenditure on this relatively cheap good, and reduces the share of expenditure on the other goods. This implies that demand for the cheap good increases and for the relatively expensive good reduces. As a result, when the two goods are substitutes, labor shifts into the sector where TFP growth is highest. The opposite holds true when goods are assumed to be complements. I follow Acemoglu and Guerrieri (2008) and estimate the elasticity of substitution from real and nominal sectoral value added data (the procedure is explained in the next section); the results yield a value of the elasticity of substitution greater than one, implying that the three goods are substitutes. Furthermore, a recent report issued by the National Commission for Enterprises in the Unorganized Sector (2009) discusses how some researchers are of the view that since the cost of capital has fallen relative to labor in India, firms have been encouraged to substitute capital for labor. In addition, it states that entrepreneurs have been encouraged to take a capital-intensive route, due to excessive labor market rigidity and institutional features prevailing in labor markets.

The second characteristic of the model is non-balanced growth which exists due to differences in factor intensities and presence of a fixed factor (land) in one sector-agriculture. The equations of motion for the state variable (aggregate capital to labor ratio k) and the control variable (aggregate per capita consumption c) of the aggregate economy are

$$\frac{k_{t+1}}{k_t} = \frac{b_{it}k_t^{\alpha-1}}{\hat{\lambda}^{\alpha}}\left[1 - \frac{x_{at}c_t}{X_t y_t}\frac{1-\theta-\gamma}{1-\alpha}\Omega_1 - \frac{x_{st}c_t}{X_t y_t}\Omega_2\right] - \frac{c_t}{X_t k_t} + (1-\delta) \tag{9}$$

$$\frac{c_{t+1}}{c_t} = \beta\left(1 + \alpha b_{it+1}k_{t+1}^{\alpha-1}\hat{\lambda}^{\alpha-1} - \delta\right) \tag{10}$$

where

$$\begin{aligned}
\hat{\lambda} &= \left[\frac{\theta}{1-\theta-\gamma}\frac{1-\alpha}{\alpha}n_{at} + n_{it} + \frac{\phi}{1-\phi}\frac{1-\alpha}{\alpha}n_{st}\right] \\
\Omega_1 &= \left[\frac{1-\alpha}{1-\theta-\gamma}n_{at} + n_{it} + \frac{1-\alpha}{1-\phi}n_{st}\right] \\
\Omega_2 &= \left[\frac{1-\phi}{1-\theta-\gamma}n_{at} + \frac{1-\phi}{1-\alpha}n_{it} + n_{st}\right]
\end{aligned}$$

and $X_t = x_{at} + x_{st} + 1$, $x_{at} = \frac{p_{at}c_{at}}{c_{it}}$ and $x_{st} = \frac{p_{st}c_{st}}{c_{it}}$, $y_t = p_{at}y_{at} + y_{it} + p_{st}y_{st}$

In this economy, non-balanced growth is characterized by aggregate output, aggregate consumption and aggregate capital to labor ratio, growing at different rates. Notably, if the values of factor shares are equal across the sectors, and no fixed factor is used in agriculture, then this model exhibits a balanced growth path. This is the case discussed in Ngai and Pissarides (2007) where there exists a saddlepath equilibrium and stationary solutions for the aggregate consumption and the aggregate capital to labor ratio.

6 Calibration

6.1 Methodology

I now assess whether the model can replicate the sectoral transformation witnessed by the Indian economy between 1980-2005. In particular, I evaluate the performance of the model in matching the quantitative changes in sectoral output and sectoral employment observed in the data. I also report the average annual growth rates of sectoral output and sectoral employment shares implied by the model and compare them with their data counterparts.

Each period in the model is assumed to be one year. The computational experiment conducted is as follows. For each sector, I use the calibrated factor income shares and sectoral TFP growth rates from the baseline growth accounting exercise. The depreciation rate is set at 5 percent in each period. The subjective discount factor, β, is calibrated to the average Indian real interest rate during 1980-2005 (about 7 percent) less the assumed rate of depreciation of capital (5 percent).

The elasticity of substitution parameter ϵ and utility weights ω_a, ω_i and ω_s are obtained through a regression equation, similar to the procedure followed by Acemoglu and Guerrieri (2008). In particular, the household's utility maximization imply the following first order

conditions in sector $j = \{a, s\}$

$$\frac{p_s c_s}{p_a c_a} = \frac{\omega_s}{\omega_a} \left(\frac{c_s}{c_a} \right)^{\epsilon}$$

Using market clearing in sector $j = \{a, s\}$ the above can be expressed as

$$\frac{p_s y_s}{p_a y_a} = \frac{\omega_s}{\omega_a} \left(\frac{y_s}{y_a} \right)^{\epsilon}$$

I regress the log of the ratio of real value added on the log of the ratio of nominal value added between services and agriculture for the sample period. This estimation yields a value of ϵ to be about 0.81 [14]. From the intercept of this equation, I can determine the value of $\frac{\omega_s}{\omega_a}$. A similar regression using real and nominal value added data of services and industry, along with investment data (in the industrial sector, consumption +investment = output) is used to obtain a value of $\frac{\omega_s}{\omega_i}$. Since the utility weights sum to 1, the individual values for these weights are determined. Once the elasticity of substitution and the utility weights are known, I solve for the levels of initial TFP in the three sectors using the same equations as specified above, and assuming they hold true for $t = 1$. These TFP levels in the initial period - b_{a0}, b_{i0}, b_{s0} can be best be determined up to a scale factor. Setting the value of b_{i0} to 1 in the initial period, I obtain b_{i0} and b_{s0} by ensuring that the ratio of the share of agricultural to services output and that of the share of industrial to services output as implied by the model is equivalent to what is seen in the data for 1980.

The parameter values are presented in Table 4.

7 Results

The trends in sectoral output shares implied by the model and those observed in the data are presented in Figure 5. With respect to value added in the three sectors, the model tracks the data closely and can capture the declining share of agricultural output, the increasing share of industry and the rapidly growing share of services in aggregate GDP throughout the sample period.

Sectoral employment share trends are displayed in Figure 6. While the model can replicate the trend in the share of industrial employment, it overpredicts the level of employment share in services at the expense of agriculture and underestimates the level of employment in agriculture. That is to say, the model predicts agricultural employment share to be much lower in 1980 than what is observed in the data and also implies a faster movement of labor

[14] The R^2 for this regression is = 0.978 and all the coefficients are significant at the 5 percent level of significance.

out from this sector when compared to the trend seen in the data. With respect to service's employment share, the model overpredicts the level of the shares over the entire period, although it captures the trend of increasing employment shares in this sector; predicts the growth rate of this increase to be similar to what is observed in the data. The inability of the model to capture the correct level of employment shares in the agricultural and service sector over the sample period can be explained as follows.

The model implies that the shares of sectoral output and shares of sectoral employment are similar in magnitude. This is a feature of the Cobb-Douglas production function and is hard wired in the model, given that the production parameters are those as obtained from the growth accounting exercise. Define A as output share in agriculture, I as output share in industry and S as output share in services. Then it can be shown that

$$A = \frac{p_a y_a}{p_a y_a + y_i + p_s y_s} = \frac{\left(\frac{1-\alpha}{1-\theta-\gamma}\right) n_a}{\left(\frac{1-\alpha}{1-\theta-\gamma} - \frac{1-\alpha}{1-\phi}\right) n_a + \left(\frac{\alpha-\phi}{1-\phi}\right) n_i + \left(\frac{1-\alpha}{1-\phi}\right)}$$

$$I = \frac{y_i}{p_a y_a + y_i + p_s y_s} = \frac{n_i}{\left(\frac{1-\alpha}{1-\theta-\gamma} - \frac{1-\alpha}{1-\phi}\right) n_a + \left(\frac{\alpha-\phi}{1-\phi}\right) n_i + \left(\frac{1-\alpha}{1-\phi}\right)}$$

$$S = \frac{p_s y_s}{p_a y_a + y_i + p_s y_s} = \frac{\left(\frac{1-\alpha}{1-\phi}\right) (1 - n_a - n_i)}{\left(\frac{1-\alpha}{1-\theta-\gamma} - \frac{1-\alpha}{1-\phi}\right) n_a + \left(\frac{\alpha-\phi}{1-\phi}\right) n_i + \left(\frac{1-\alpha}{1-\phi}\right)}$$

The above equations imply the following: in the extreme case, if the values of capital (or labor) shares in the three sectors are numerically close to each other, then the behavior of sectoral output and employment mimic each other. In this paper the capital shares have been calibrated from the data and have similar numerical values across sectors[15]; hence the level and the growth rate of sectoral output measure closely to the level and the growth rate of sectoral employment. Since my objective is to evaluate the effect of policy reforms following liberalization on sectoral output, particularly for services, the model's inability to match the sectoral employment levels and growth rates, though discernible, remains a non-issue. In section 10 of the paper, I present a version of the model in which wages are higher in industry and services than in agriculture. The idea is to examine whether this modification improves the ability of the model to capture the sectoral employment shares.

To gain further insight into the performance of the model, I calculate the average annual growth rates of the shares of output and employment in each of the three sectors for

[15] In agriculture the share is is 0.42 (share of capital + share of land), in industry it is 0.51 and in services 0.37

the given period. The growth rates implied by the model and those calculated from the data are displayed in Table 5. The model implies that the share of agricultural output declined at an average annual rate of 2.3 percent. The growth rate calculated from the data is about 2.2 percent, therefore the model comes very close to matching the data. With respect to the share of industrial output, the model implies a growth of 0.1 percent, which is lower than the growth of 0.3 percent seen in the data. For the service sector, the model indicates that the share of this sector in total output increases at an average annual rate of 1.4 percent. This share grows at an average annual rate of 1.3 percent in the data, and therefore the model does a good job here.

With respect to employment share in the service sector we observe that the model predicts perfectly the growth seen in the data - of 1.4 percent. In the other two sectors, the model's predictions for the growth in these shares are similar to the growth in sectoral output shares. The reason for this has been discussed above. Therefore in the industrial sector, while the data implies the share of employment to be growing at a rate of 1.1 percent, the model suggests this to be much lower at 0.1 percent. In the agricultural sector, the model predicts the share of employment to decline at a much faster rate of 2.3 percent, whereas, in the data, the movement of labor is slower at 0.9 percent.

8 Effect of Liberalization

The growth accounting results indicate that there was a rapid increase in service sector TFP in the post-liberalization period in India. Table 6 reproduces the pre- and post-liberalization sectoral TFP growth rates obtained from the growth accounting exercise. These results show that there was a rapid increase in service's TFP from 2.68 percent before liberalization to 3.85 percent following it. In the agricultural sector, TFP growth slowed from 2.19 percent during 1980-1990 to 1.71 percent in the 1991-2005 period. Industrial TFP growth increased from 0.86 percent in the pre-liberalization period to 1.42 percent in the post-liberalization period.

In order to assess the importance of the changes in TFP growth rates that occur following economic liberalization in 1991, I ask the following: What would the level and the growth rate of each sector's share in aggregate output in the 1991-2005 period be if TFP growth rate had not changed after 1991? To start with, I simulate the model by assuming that the average annual growth rate of sectoral TFPs for the 1980-2005 period is equal to the

pre-liberalization (1980-1990) average annual growth rate (Scenario 1). Then, I compare this economy with the one in which I take into account the higher TFP growth rates observed in post-liberalization era (Scenario 2). Thus, I simulate the model by using the average pre-liberalization sectoral TFP growth rates for the 1980-1990 period and the average post liberalization sectoral TFP growth rates for the 1991-2005 period.

Figure 7 depicts the time paths of sectoral output shares under the two scenarios and compares these with the trends observed in the data. The results are also presented in terms of average annual growth rates in Table 7. In the simulation in which I only use the pre-liberalization TFP growth rates, the share of output in agriculture declines at a rate of 0.8 percent during 1991-2005. The model under scenario 2 does much better, as it predicts a declining growth of 3.8 percent, measuring closer (albeit, a slight overestimation) to the negative growth rate of 2.8 percent observed in the data.

With regard to the trend in the share of industrial output, the model implies a slight negative decrease in the share of industrial output of 0.5 percent in the first simulation and a slightly positive growth of 0.3 percent in the second scenario. The rate of decline of this sector's share is seen to be small, 0.1 percent in the data and we can infer from this that industrial share of output saw negligible.

In the absence of the TFP growth rate increase after liberalization, the share of service sector output increases at a rate of 0.9 percent. The corresponding growth in service sector output share when I allow for TFP growth rate to increase following liberalization, is about 2.2 percent in the model, and about 1.7 percent in the data. Without the increase in TFP following liberalization, the model can account for only one-half of the growth in the share of service sector output. This low growth in the output share of services in scenario 2 is due to slower resource reallocation from agriculture to services, as compared to the scenario in which TFP growth is allowed to increase after liberalization. When only the pre-liberalization TFP growth rates are used, the difference in sectoral TFP growth rates, which is the principal factor guiding the reallocation of resources across sectors, becomes relatively smaller. As the sectoral differential between TFP growth rates becomes less potent, the difference between the price of the service good and the price of the agricultural good becomes smaller. Hence the household is less willing to substitute consuming the service good, thereby affecting the output demanded and hence produced in this sector.

9 Explaining the Rapid Growth of Share of Services in Indian GDP

A number of explanations have been offered to account for the rapid growth of the service sector share in Indian GDP after liberalization. In this section, I discuss each of the arguments and also present mine. I find that the liberalization policies adopted by India from 1991, and especially the deregulation and privatization of business and communications services, explain the improvement in service sector TFP and hence, the dominance of service sector activity in India's GDP growth.

Splintering: One 'supply- side explanation' discusses the role of splintering. Splintering involves switching to a more service-input intensive method of organizing production, which can arise as a result of increasing specialization as the economy matures. Gordon and Gupta (2004) use input-output coefficients for the 1989/1990-1993/94 period to measure the usage of services by agriculture and industry in the early 1990s. They find that splintering could have added only about one- fourth of one percentage point to annual services' value added growth during the early 1990s. Following an identical methodology, Singh (2006) uses input-output coefficients from the 1998-1999 data and finds that splintering makes no contribution to service's value added growth during the entire 1990-2000 period.

Demand: The 'demand-side explanation' argues that an increase in the share of service's output in GDP is due to rapid growth of final demand for services, resulting from a high income elasticity of demand for services. Gordon and Gupta (2004) find that this argument has little merit in the Indian case. They argue that prior to the 1990s, final consumption of services was growing at a lower rate than output of services and, after 1990, the two grew at roughly equivalent rates. Hence, the income elasticity argument could only hold if there was a behavioral change in the 1990s and there is no a priori reason to expect this to have occurred. Moreover, they reason that, if the demand-side explanation was true, the price of services relative to the overall price level in the economy should have increased. The Indian data reveal that this ratio actually decreased after 1991. Additionally, recent work by Falvey and Gemmell (1996) has tended to reject the income-elastic demand for services overall but confirm a wide range of income elasticity estimates (above and below unity) across different types of services.

TFP

The above explanations have little merit in explaining rapid service-sector growth in India. Moreover, the growth accounting results show that changes in TFP were crucial for driving growth in the service sector, especially after liberalization. The question is whether and which of the liberalization reforms of 1991 were the mechanisms which resulted in productivity growth in the service sector? The economic liberalization of 1991 involved a myriad of policy changes. Some of the important policy reforms included tariff reductions, reduction in export controls, removal of quotas, entry of foreign direct investment (FDI) in some sectors and deregulation and privatization in the service and industrial sectors. Which of these policy changes, if any, can best explain the rapid growth of service sector productivity and service sector output in India?

Trade liberalization: Major policy changes carried out within the scope of trade liberalization involved tariff reductions, reduction in export controls, repeal of quotas and removal of import licensing. Prior to 1991, India had very high tariff rates, with the aim of turning quota rents into tariff revenues. Pre liberalization, about 439 items were subject to export controls, but this number was brought down to about 296 in 1992 (Panagariya (2004)).

Although much progress was made in liberalizing the trade regime in India, India remained a relatively closed economy during much of the 1990s. Rodrik and Subramanian (2004) use a gravity model and conclude that India became a 'normal' trader only by 2000 (for the 1980-1999 period the coefficient of openness on India was negative and significant), as compared to China, for which trade was significant during the entire 1980-2000 period. The World Bank Report (2004) reports that the average tariff rate in India (inclusive of customs duties and other general and selective protective levies) in 2002-03 was still high at 35 percent. With respect to exports of services, there is no refutation of the fact that, as a share of service sector GDP, these exports grew following trade liberalization. However, by 2003, service sector exports were about 8 percent of service's GDP, and about 4 percent of aggregate GDP. Given how small these numbers are, an export-led growth hypothesis of service sector growth is difficult to support[16].

[16]In comparison, the average share of merchandise exports to industrial value added during the 1960-1985 period in two of the East Asian countries -Taiwan and South Korea- was about 82 & 53 percent respectively; the share of merchandise exports in aggregate value added was about 35 and 17 percent respectively.

FDI in services: Gordon and Gupta (2004) and Singh (2006) discuss the role of FDI in the service sector, particularly its growth in the telecommunication sector after liberalization. The channel through which FDI and foreign technology spills over to domestic firms deserves some merit as an explanation of enhancing productivity growth in this sector. However, while it is true that services- particularly telecommunications- have been attracting a large share of FDI, FDI inflow as a percentage of service sector GDP has been very small. The Handbook of Industrial Policy and Statistics 2003-05 reports the FDI inflows statistics in various sub-sectors of the economy. Table 8 reproduces these values for the sub-sectors in services and also reports service sector GDP for the 1991-2003 period. During 1991-2002, the cumulative share of service sector FDI inflows in service sector GDP is 0.3 percent and falls to 0.2 percent by 2003. The small share of FDI inflows in this sector seems unlikely to account for the magnitudes of productivity and output growth in the Indian services.

Human Capital: Since services are assumed to be relatively skill intensive, one could argue that education plays a big role in driving growth in this sector. Bosworth et al. (2007) conduct growth accounting for each of the three sectors (agriculture, industry and services) for the Indian economy between 1960 and 2004. In each sector, output is produced by capital, labor and human capital, measured as education. For the 1980-2004 period, they report that TFP in services grew at an average annual rate of 3 percent. Their results indicate that the average annual growth of education as a factor of production in the service sector is small at 0.4 percent and accounts for 14 percent of service's output growth. These authors also provide data from National Survey Sample Organisation (NSSO) in India about the educational attainment of Indian workers aged between 15 to 64 years. These data are presented in Table 9 below. A glance at the table reveals that the percentage of workers with graduate education is very small, 6 percent in 2004, suggesting that education cannot explain the increase in productivity and output gains in services. Verma (2011) also finds that human capital (schooling) does not have a significant impact on measured sectoral TFP growth rates.

Deregulation and Privatization: Prior to liberalization, the service sector had been subject to heavy government intervention. There was a conspicuous dominance of the public sector in the key sectors of insurance, banking and telecommunications.

Following liberalization, there was an active deregulation of some sectors, and entry of private firms was allowed in the service sector. Prior to 1991, insurance was a state monopoly.

In 1999, the Indian Parliament passed the Insurance Regulatory and Development Authority (IRDA) Bill, which established an Insurance Regulatory and Development Authority and permitted private sector participation in the insurance sector. Similarly, the banking sector was opened up to allow private banks to operate, following the recommendations of the Narasimhan Committee in 1991-92. Another sector which witnessed massive growth in its output was telecommunications. Until the early 1990s, this sector was a state monopoly, but with the creation of the National Telecommunications Policy in 1994, the doors were opened to the private sector to provide for cellular, as well as basic and value-added, telephone services. The Handbook of Industrial Policy and Statistics 2003-2005 lists that in 2003, the share of public sector investment in commodity producing enterprises as 60.36 percent, while the corresponding share in enterprises rendering services was much less, at 35.6 percent.

Figure 8 shows how shares of the service sub-sectors in aggregate GDP grew for the 1980-2003 period. Clearly, the telecommunication, and the banking and insurance sectors witnessed rapid growth after liberalization [17]. The growth in the share of the telecommunication sector is particularly notable. In this sector, deregulation as well as technological progress occurred and may have promoted the rapid growth of output in a short span of time. Information technology, as a sub-sector of activity, is part of business services. Further disaggregated data in the national accounts are not available to see how this sector grew, but Singh and Srinivasan (2004) report that the share of this sector in GDP was about 1 percent in late 1990s. Even though this sector, in itself, may not account for a large share of Indian GDP, its large spillover effects to the other sectors has enabled growth in the telecommunication, banking and the insurance sectors.

I conclude that deregulation, privatization and, quite possibly, information technology promoted the growth of output service sector output during the 1991-2005 period.

10 Difference in Wages

In this section, I present a simple extension of the model in which firms in the industrial and service sectors pay a higher wage to the worker than that paid in the agricultural sector. The question in mind is that by allowing for wages to be different across sectors, can the model do a better job matching the levels of sectoral employment? The intuition is that by allowing for higher wages, firms in industry and services find it relatively more expensive to

[17] The growth in banking and insurance started during the late 1980s as some deregulation took place then, although major reform followed after liberalization in 1991.

employ labor. Hence their demand for labor would decrease while that in agriculture would increase. This would improve the fit of the sectoral employment shares to the data.

The wage differential is introduced by assuming that the firms in industrial and service sectors pay a wage $(1+\tau_j), \quad j = \{i, s\}$ times higher than the wage paid in the agricultural sector during the entire time period (See Buera and Kaboski (2009)). These firms now face the following problem

$$\max_{\{k_{jt}, n_{jt}\}} \{y_{jt} - r_{jt}k_{jt} - w_t(1+\tau_j)n_{jt}\}$$

subject to

$$y_{jt} = b_{jt}k_t^{\nu_j} n_t^{1-\nu_j}, \quad \nu_j \in (0,1) \quad j = \{i, s\}$$

The budget constraint faced by the household is now

$$p_{at}c_{at} + c_{it} + p_{st}c_{st} + k_{t+1} - (1-\delta)k_t = r_{kt}k_t + w_t n_{at} + w_t(1+\tau_i)n_{it} + w_t(1+\tau_s)n_{st} + R_{lt}$$

The structure of the rest of the economy remains the same as discussed in section 5. The parameter values as given in Table 4, also remain unchanged. I assume $\tau_i = \tau_s = \tau$ and calibrate its value to match the relative differential in wages of rural and urban males (at primary level of schooling) in 1983 (See Kochar (2004)). This exercise yields a value of τ as 0.28.

Using the sectoral TFP growth rates as calculated by (baseline) growth accounting for the period 1980-2005, the results of the modified model are depicted in Figures 9 and 10. As compared to the baseline case, the model's predictions for the share of employment in the three sectors improves. In the initial year, 1980, about 55 percent of labor is employed in the agricultural sector, while industry accounts for about 16 percent and services employ about 29 percent of the labor force. This is a marked improvement over the predictions given by the baseline model: 38 percent in agriculture, 20 percent in industry and about 42 percent in services. As stated above, firms in the industrial and agricultural sectors have to pay a higher wage to hire labor, employment in these sectors reduces, while employment in the relatively cheaper sector - agriculture- increases. Since the parameter τ is assumed to be constant at 0.28 for the entire sample period there is no significant difference in the trends in sectoral employment shares. These are not very different compared to the baseline case, as seen in the figure [18].

[18] The growth rate results in this case are not very different quantitatively from the baseline case, since we assume the distortion parameter to be constant for the period; hence for brevity i do not present these.

The introduction of higher wages in industry and services has an impact on the sectoral output shares. Share of total output in agriculture now increases to about 48 percent (as compared to 38 percent earlier) and that of services decreases to about 30 percent (from about 38 percent). The share of output in industry stays about the same as in the baseline version of the model. Moreover, in terms of how these sectoral output shares behave over time, the growth rates are not significantly different across the two versions, as is evident from the slope of the graphs.

The above illustration highlights that by introducing higher wages, and without re-calibrating the model, one can improve the fit of the sectoral employment shares to the data. Since the initial levels of sectoral TFPs have not been re-calibrated to match their initial levels as seen in the data, the model's predictions with respect to the share of output in agriculture and services in 1980 suffers. However, my objective is to emphasize that keeping all the parameter values unaltered and modifying the assumption of equal wages across sectors to that in which two sectors employ labor at higher wages enables the model to better fit the sectoral employment data. A more careful exercise will involve re-calibrating the initial TFP levels, as well as, data on the behavior of sectoral wages over time. This is a challenging task since data on sectoral wages are not readily available, but remains an avenue to be explored in the future.

11 Conclusion

This paper accounts for the rapid growth of the service sector in one of today's low income, rapid growing countries - India. India serves as a good example of a service-driven economy, as is evident from the empirical exercise conducted. This empirical exercise reveals that, among a few low-income countries which have been growing at a rate higher than 2 percent per annum, economic growth in India has been heavily driven by its service sector. The first part of this paper discusses the trends of sectoral output shares, sectoral employment shares and sectoral TFPs observed in the Indian data and conducts a sectoral growth accounting exercise for India during the period 1980-2005. The results from this exercise show that changes in total factor productivity (TFP) were the largest source of service sector value added growth. In addition, during the same period, measured service sector TFP growth was much higher than measured TFP growth in agriculture and industry, and increased substantially following the inception of market-based liberalization policies from

1991.

In the second part of this paper, I develop a three-sector growth model to evaluate the quantitative performance of differential TFP growth across sectors in accounting for value added and employment growth in the sectors. The preference structure is assumed to be homothetic, where sector specific TFP growth combined with a non- unitary elasticity of substitution results in structural change and non-balanced economic growth. The model is calibrated to Indian data in which average rates of TFP growth by sector are fed exogenously into the model, which is then simulated for the 1980-2005 period. The results suggest that the model can replicate the evolution of value added shares over the sample period. In addition, the model can quantitatively match the growth rates of the value added shares of these sectors as well.

The limitation of the model lies in that it cannot match the levels of sectoral employment in the three sectors. This is a result of the Cobb-Douglas production functional form in conjunction with the numerical values of the production parameters and is hardwired into the model. A simple extension of the model demonstrates that if wages in industry and services are higher than in agriculture, then the fit of the model with respect to employment shares improves. There is no significant change observed in the trends of sectoral output and employment share. Another limitation of my analysis is with respect to the sectoral growth accounting exercise I conduct. Ideally, in multi sector growth models, gross output data are the right measure of output produced in a sector and productivity analysis should be based on these. However, given the non-availability of a long enough time series on sectoral gross output in India, I use another highly correlated measure: sectoral value added series.

In order to highlight the importance of the post-1991 increase in service sector TFP, I conduct an experiment which shows that the model's performance improves significantly when the post-1991 increase in service sector TFP growth is accounted for. I argue that the increase in service sector TFP was a result of the liberalization policies adopted by India. The economic liberalization that India initiated in 1991 involved a myriad of policy changes, consisting of tariff reductions, reduction in export controls, removal of quotas, entry of FDI in some sectors and deregulation and privatization in the service and industrial sectors. The above listed policy reforms have little potential to explain the takeoff in services productivity following liberalization. On the basis of empirical data and analysis, I reject the above explanations and argue that a better explanation of why service sector TFP grew

after 1991 was because of a change in policy. In particular, deregulation and privatization of business, insurance and communication services can explain the rapid increase in service sector TFP, and hence the dominance of service sector activity in India's GDP growth.

A number of questions can be raised on the basis of this study. Why has the output in the industrial sector grown modestly? Why did agricultural output and productivity decline following liberalization? These are all interesting issues and are left to be explored in future research.

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Data Appendix

1. Classification according to current daily status approach (cds): The activity pattern of people, particularly in the unorganized sector, is such that a person might be pursuing more than one activity during a week and sometimes even during a day. In the current daily status, up to two activity statuses were assigned to a person on each day of the reference week. The unit of classification was thus half day in the cds. In assigning the activity status on a day, a person was considered working for the entire day if he had worked four hours or more during the day. If he had worked one hour or more but less than four hours, he was considered working (employed) for half day and seeking/available for work (unemployed) or not available for work (not in labor force) for the other half day, depending on whether he was seeking/available for work or not. On the other hand, if a person was not engaged in any work even for one hour, but was seeking or available for work for four hours or more, he was considered unemployed for the entire day. If he was available for work for less than four hours only, he was considered unemployed for half of the day and not in labor force for the other half of the day. A person who neither had any work to do nor was available for work even for half of the day was considered not in the labor force for the entire day and was assigned one or two non-economic activity status codes. The aggregate of person days classified under the different activity categories for all the seven days gave the distribution of person days by activity category during an average week over the survey period of one year.

Table 1: Growth Accounting - Baseline results

	Agriculture	Industry	Services
Factor share			
capital	0.22	0.51	0.37
labor	0.58	0.49	0.63
land	0.2		
Decomposition of average annual changes in real value added (%)			
Entire period 1980-2005			
Growth in real value added	3.25	6.25	7.22
due to capital	0.58	3.34	2.24
	(17.9)	(53.5)	(22.4)
due to labor	0.67	1.57	2.2
	(20.6)	(25.0)	(30.5)
due to land	0.08		
	(2.5)		
due to TFP	**1.91**	**1.29**	**3.27**
	(58.6)	(20.7)	(45.4)
Pre liberalization 1980-1990			
Growth in real value added	4.27	6.78	6.63
due to capital	0.68	3.79	1.26
	(15.9)	(55.8)	(18.9)
due to labor	1.22	2.10	2.59
	(28.6)	(30.9)	(39.1)
due to land	0.14		
	(3.4)		
due to TFP	**2.19**	**0.86**	**2.68**
	(51.3)	(12.7)	(40.4)
Post liberalization 1991-2005			
Growth in real value added	2.48	5.77	7.77
due to capital	0.53	3.03	1.86
	(21.5)	(52.4)	(24.0)
due to labor	0.22	1.28	1.92
	(9.0)	(22.1)	(24.7)
due to land	0.01		
	(0.6)		
due to TFP	**1.71**	**1.42**	**3.85**
	(68.9)	(24.7)	(49.5)

The number in parenthesis is the % contribution of the factor to real value added growth.

Table 2: Growth Accounting - GTAP factor shares

	Agriculture	Industry	Services
Factor share			
capital	0.21	0.61	0.5
labor	0.41	0.39	0.5
land	0.38		
Decomposition of average annual changes in real value added (%)			
Entire period 1980-2005			
Growth in real value added	3.25	6.25	7.22
due to capital	0.56	4.00	2.18
	(18.1)	(65.1)	(31.4)
due to labor	0.47	1.25	1.75
	(15.4)	(20.3)	(25.2)
due to land	0.01		
	(5.0)		
due to TFP	**2.05**	**0.97**	**3.16**
	(66.9)	(15.8)	(45.5)
Pre liberalization 1980-1990			
Growth in real value added	4.27	6.78	6.63
due to capital	0.65	4.53	1.70
	(15.1)	(66.8)	(25.6)
due to labor	0.86	1.67	2.06
	(20.2)	(24.6)	(31.0)
due to land	0.27		
	(3.4)		
due to TFP	**2.45**	**0.56**	**2.77**
	(57.3)	(8.3)	(41.8)
Post liberalization 1991-2005			
Growth in real value added	2.48	5.77	7.77
due to capital	0.51	3.62	2.52
	(20.5)	(62.7)	(32.4)
due to labor	0.16	1.02	1.52
	(6.3)	(17.6)	(19.6)
due to land	0.03		
	(1.1)		
due to TFP	**1.78**	**1.10**	**3.59**
	(71.7)	(19.1)	(46.2)

The number in parenthesis is the % contribution of the factor to real value added growth.

Table 3: Growth Accounting - Capital share of one-third

	Agriculture	Industry	Services
Factor share			
capital	0.24	0.33	0.33
labor	0.56	0.67	0.67
land	0.2		
Decomposition of average annual changes in real value added (%)			
Entire period 1980-2005			
Growth in real value added	3.25	6.25	7.22
due to capital	0.63	2.16	1.44
	(20.8)	(35.0)	(20.5)
due to labor	0.65	2.14	2.34
	(21.2)	(34.6)	(33.3)
due to land	0.08		
	(2.6)		
due to TFP	**1.69**	**1.88**	**3.24**
	(55.4)	(30.4)	(46.1)
Pre liberalization 1980-1990			
Growth in real value added	4.27	6.78	6.63
due to capital	0.74	2.45	1.12
	(17.3)	(36.1)	(16.9)
due to labor	1.18	2.87	2.76
	(27.6)	(42.3)	(41.6)
due to land	0.14		
	(3.4)		
due to TFP	**2.14**	**1.40**	**2.65**
	(50.2)	(20.6)	(40.0)
Post liberalization 1991-2005			
Growth in real value added	2.48	5.77	7.77
due to capital	0.58	1.96	1.66
	(23.5)	(33.9)	(21.4)
due to labor	0.21	1.74	2.04
	(8.7)	(30.2)	(26.3)
due to land	0.01		
	(0.6)		
due to TFP	**1.61**	**2.01**	**3.93**
	(65.0)	(34.8)	(50.5)

The number in parenthesis is the % contribution of the factor to real value added growth.

Table 4: Calibrated parameters

Parameters	**Description**	**Values**
θ	capital share in agriculture	0.22
γ	land share in agriculture	0.2
α	capital share in industry	0.51
ϕ	capital share in services	0.37
b_{a0}	initial TFP level in agriculture	5.2514
b_{i0}	initial TFP level in industry	1
b_{s0}	initial TFP level in services	2.5749
g_{at}	growth rate of TFP in agriculture	0.0191
g_{it}	growth rate of TFP in industry	0.0129
g_{st}	growth rate of TFP in services	0.0327
β	discount factor	0.98
δ	depreciation rate	0.05
ω_a	weight on agricultural good	0.32
ω_i	weight on industrial good	0.31
ω_s	weight on service good	0.37
$1/(1-\epsilon)$	elasticity of substitution	5.26

Table 5: Average annual growth rates (%), 1980-2005

Variable	**Data**	**Model**
Share of output in agriculture	-2.2	-2.3
Share of output in industry	0.3	0.1
Share of output in services	1.3	1.4
Share of employment in agriculture	-0.9	-2.3
Share of employment in industry	1.1	0.1
Share of employment in services	1.4	1.4

Table 6: Pre- and post-liberalization TFP growth rates

TFP growth rate (%)	Agriculture	Industry	Services
Pre-liberalization 1980-1990	2.19	0.86	2.68
Post-liberalization 1991-2005	1.71	1.42	3.85

Table 7: Average annual growth rates during 1991-2005

	Data	Model using pre-liberalization TFPs	Model using post-liberalization TFPs
Share of output in agriculture	-2.8	-0.8	-3.8
Share of output in industry	-0.1	-0.5	0.3
Share of output in services	1.7	0.9	2.2

Table 8: FDI and GDP in Indian Services

	1991-2002	2003
FDI inflows:	Rs. Million cumulative	Rs. Million
Telecommunications	98,994.43	7,272.59
Financial and Non-Financial Services	65,938.62	13,903.59
Consultancy Services	4,354.96	2,480.26
Hotel & Tourism	6,276.92	2,594.21
Trading	11,982.54	831.46
Total FDI in Services	187,547.47	27,082.11
Total GDP in Services	66,368,910	11,434,480
Share of FDI/GDP in Services	0.3%	0.2%

Table 9: Educational Attainment of Indian Workers Aged 15-64 (in %)

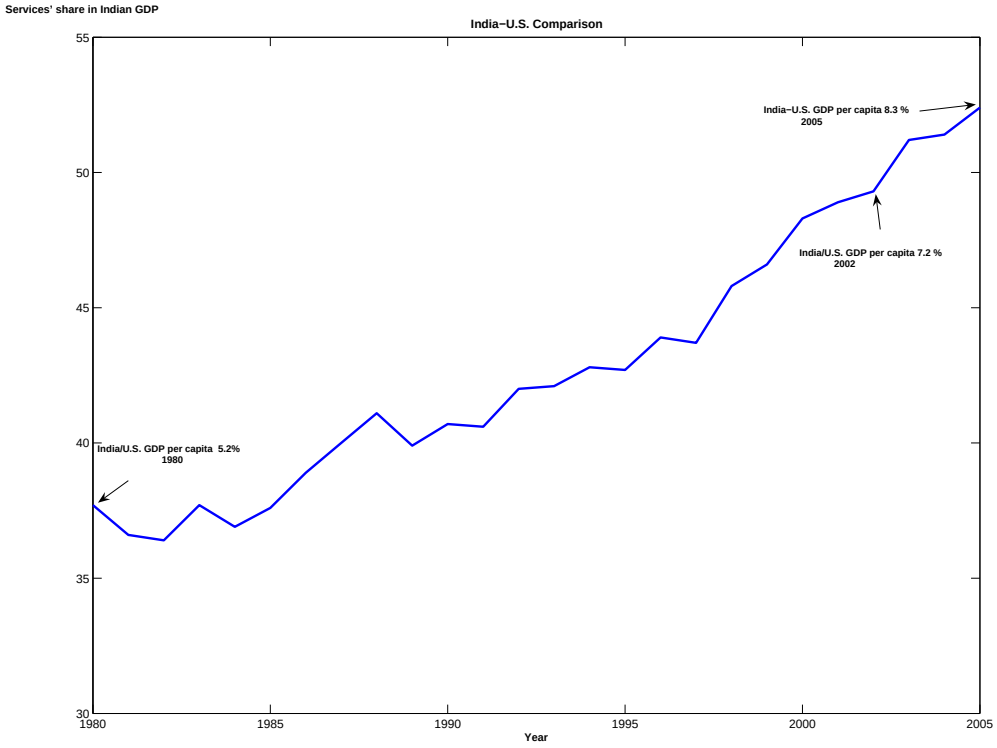
Schooling Level	1960	1983-84	1993-94	1999-00	2004
Illiterate	72.2	56.6	48.5	43.5	39.4
Below Primary		11.1	12.0	11.0	9.1
Primary		12.8	11.9	11.7	14.5
Middle	11.1	9.6	11.8	14.1	17.1
Secondary			7.5	9.3	8.9
Higher Secondary			3.7	4.5	5.1
Graduate	0.0	2.7	4.5	5.9	6.0

Table 10: Growth Rates of GDP per capita in Low-Income Countries

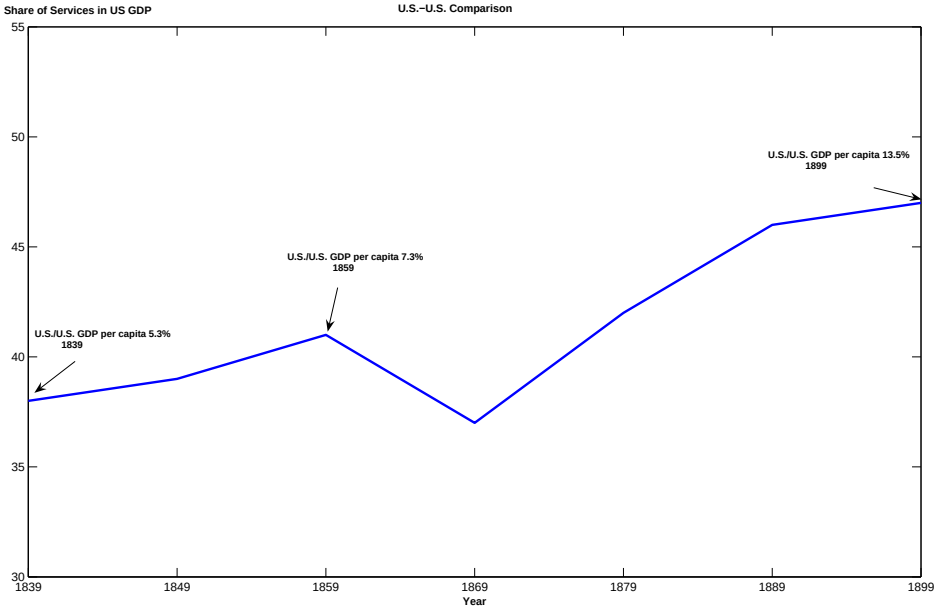
Countries	1980 **GDP per capita less than** 825 **constant** 2000 **U.S. dollars**	**Average annual growth rate (%) of GDP per capita 1980-2004**
Rapid Growers: growth rate greater than 2%		
China	186.44	8.51
Thailand	804.48	4.58
Bhutan	263.65	4.12
India	222.05	3.76
Indonesia	396.63	3.50
Sri Lanka	441.86	3.29
Chad	147.26	2.34
Lesotho	309.65	2.34
Pakistan	327.43	2.31
Bangladesh	240.51	2.16
Nepal	140.08	2.11

Table 10: (continued)

Countries	1980 **GDP per capita less than** 825 **constant** 2000 **U.S. dollars**	**Average annual growth rate (%) of GDP per capita 1980-2004**
Countries with growth rate greater than 1% but less than 2%		
Sudan	274.22	1.93
Mozambique	179.01	1.80
Burkina Faso	191.69	1.08
Countries with growth rate greater than 0% but less than 1%		
Kiribati	435.41	0.84
Mauritania	361.8	0.79
Guyana	819.41	0.79
Ghana	233.56	0.74
Senegal	405.53	0.53
Benin	292.44	0.47
Mali	220.22	0.302
Solomon Islands	597.09	0.26
Cameroon	638.19	0.15
Papua New Guinea	582.54	0.15
Gambia	327.21	0.12
Countries with growth rate less than 0%		
Kenya	435.24	-0.08
Malawi	161.7	-0.23
Guinea-Bissau	144.44	-0.23
Nigeria	425.32	-0.24
Comoros	404.63	-0.29
Rwanda	280.35	-0.48
Burundi	126.36	-0.78
Zimbabwe	598.68	-1.12
Zambia	450.51	-1.21
Central African Republic	313.57	-1.37
Togo	346.28	-1.45
Madagascar	341.81	-1.66
Niger	245.5	-1.87
Haiti	802.62	-2.57
Sierra Leone	310.4	-2.82
Congo, Dem. Rep.	251.12	-4.29
Liberia	744.48	-7.02
All Countries: Average annual growth rate 0.51%		



(a)



(b)

Figure 1: A comparison of the Indian economy relative to the U.S. economy

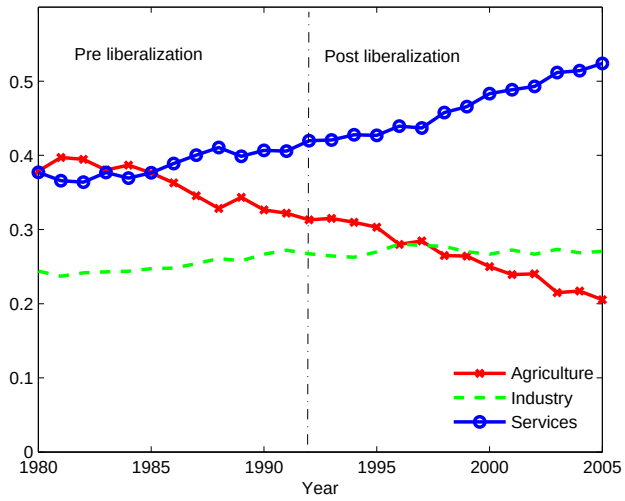


Figure 2:

Shares of Sectoral Output in GDP, 1980-2005

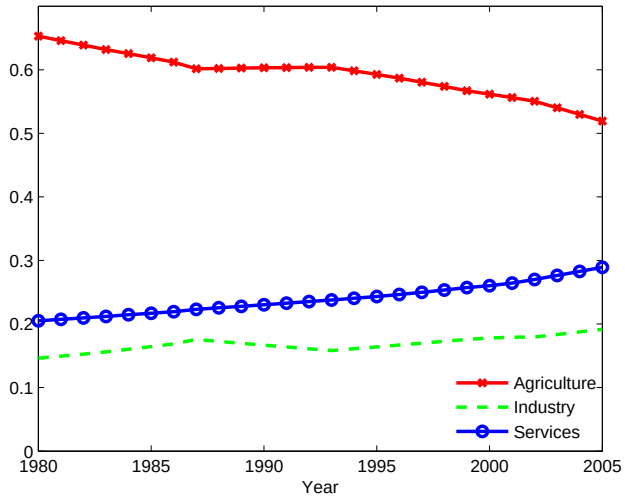


Figure 3:

Shares of Sectoral Employment, 1980-2005

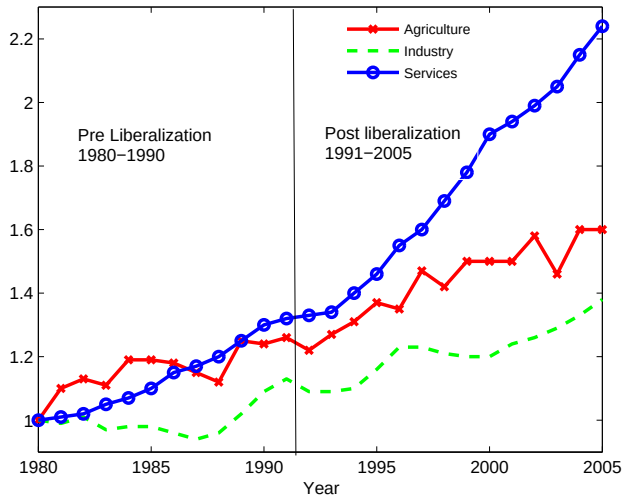


Figure 4:

Normalized Sectoral TFP Levels

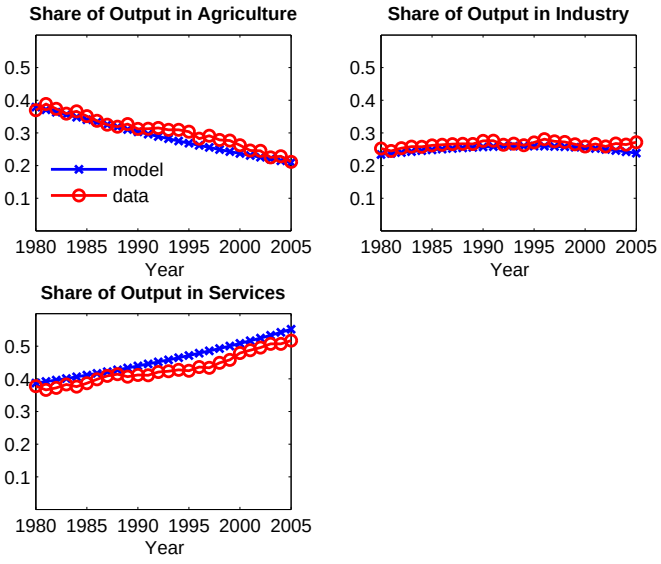


Figure 5:

Shares of Sectoral Output, 1980-2005

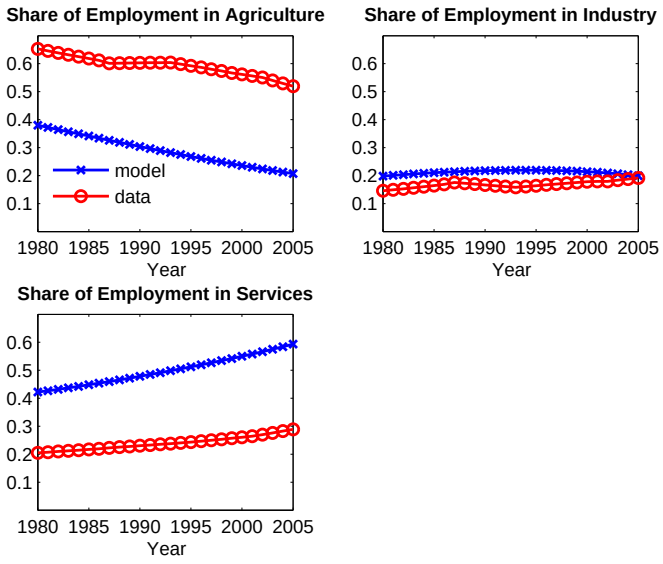


Figure 6:

Shares of Sectoral Employment, 1980-2005

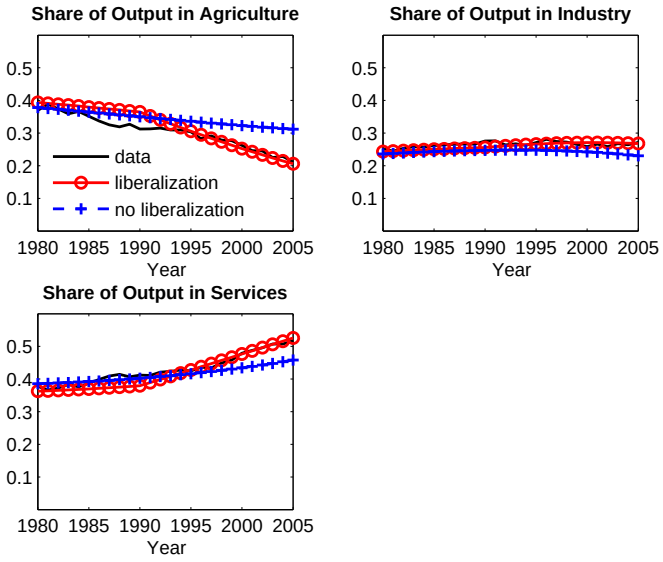


Figure 7:

Effect of Liberalization - Shares of Sectoral Output

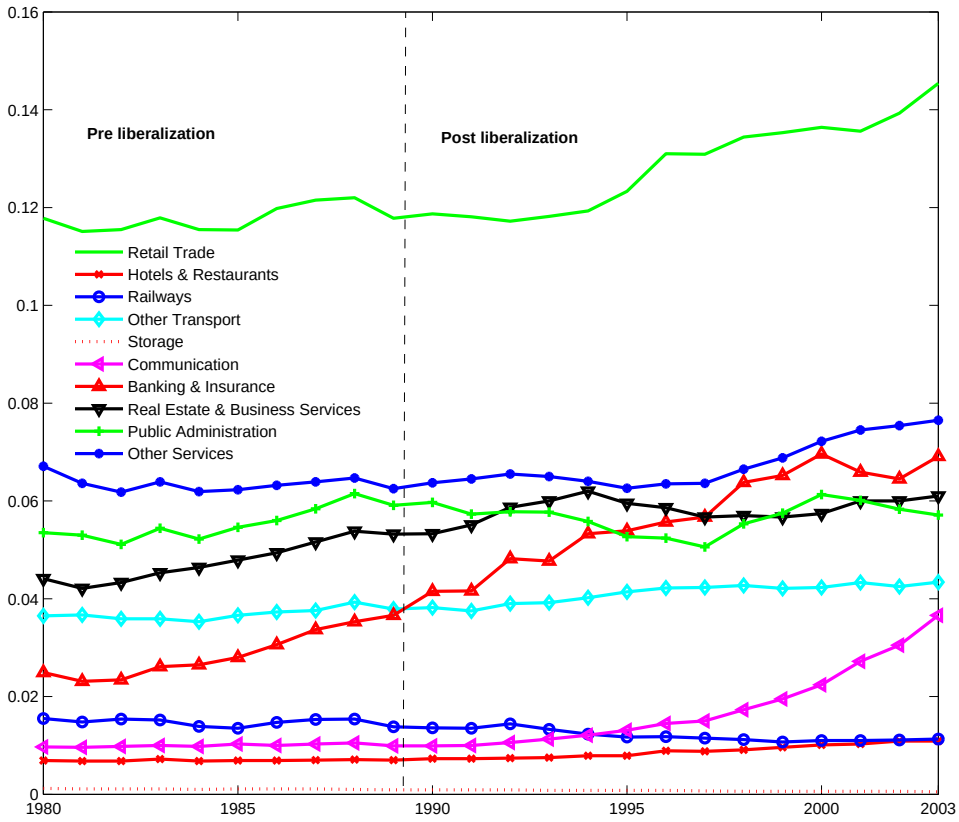


Figure 8:

Share of Output of Services Sub-sectors in Aggregate GDP

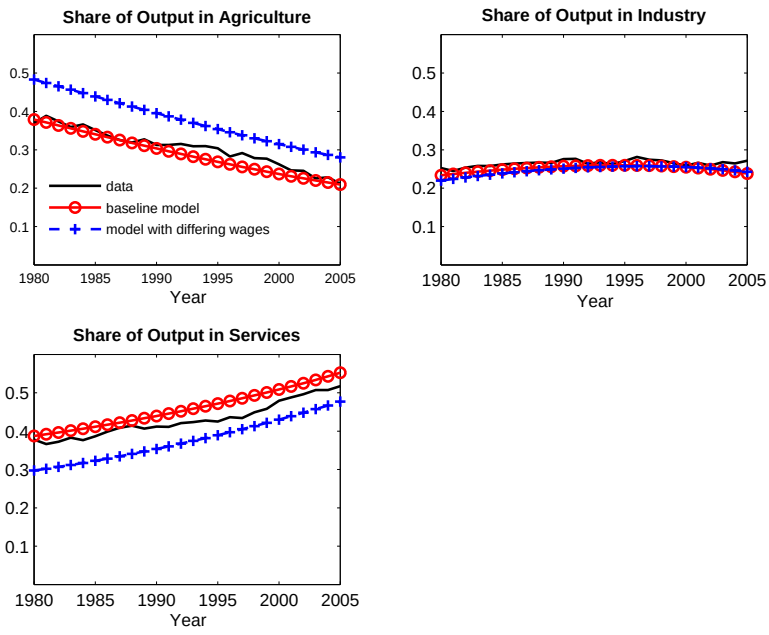


Figure 9:

Shares of Sectoral Output, 1980-2005

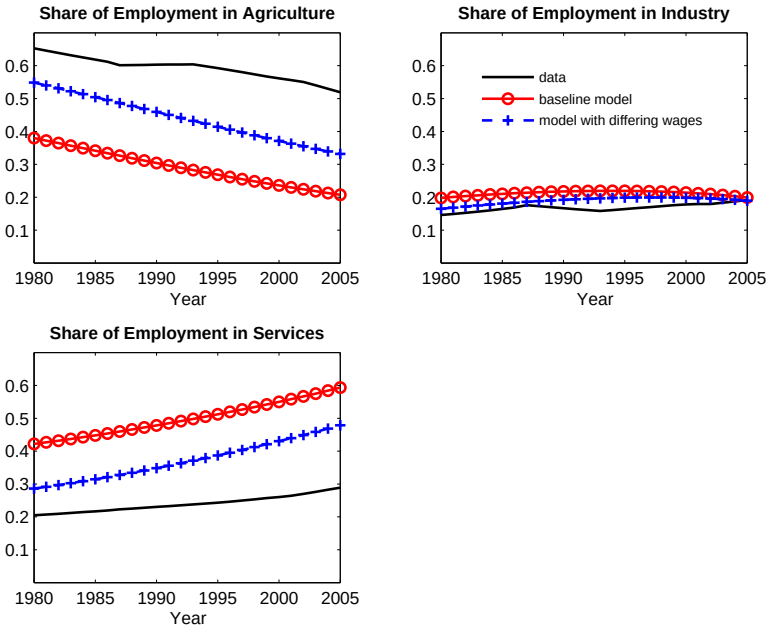


Figure 10:

Shares of Sectoral Employment, 1980-2005