Can Total Factor Productivity Explain Value Added Growth in Services?

Published in Journal of Development Economics, Volume 99, Issue 1, September 2012

Rubina Verma*†

Abstract: This paper examines the factors responsible for generating the services led growth witnessed in the Indian economy during 1980-2005. 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 service sector value added growth. A growth model with agriculture, industry and services as three principal sectors is calibrated to Indian data using sectoral TFP growth rates. The baseline model performs well in accounting for the evolution of value added shares and their growth rates, but is unable to capture sectoral employment share trends. The performance of the model with respect to value added shares improves when the post 1991 increase in service sector TFP growth following the inception of market-based liberalization reforms is accounted for. A modified version of the model with public capital can better track trends in sectoral employment shares.

JEL Codes: O14, O41, O53

Key Words: TFP, India, Services, Growth, Public Capital

*Contact Address: Assistant Professor, Department of Business Administration, Instituto Tecnologico Autonomo de Mexico (ITAM), Mexico D.F. C.P 01080, Mexico. Email:rubina.verma@itam.mx

†I am grateful to Caroline Betts, Robert Dekle, Yong Kim, Jeffrey Nugent, Vincenzo Quadrini and Guillaume Vandenbroucke for helpful comments and suggestions. I have benefited from comments received at several presentations: Dynamics, Economic Growth and International Trade, Jerusalem (June 2006), The Canadian Economics Association, Halifax (June 2007), Dynamics Seminar, USC (September 2007). I would also like to thank Barry Bosworth and Susan M. Collins for sharing data with me. I am grateful to an anonymous referee for valuable comments. All remaining errors are mine.

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% while the growth rate of real output produced in the service sector exceeded the aggregate growth rate, measuring 7.2%. In other words, the service sector's share in GDP grew at an average annual rate of 1.3% 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% of the U.S. GDP per capita, the share of services in Indian GDP was about 38%. By 2002, Indian GDP per capita had grown to 7.2% of U.S. GDP per capita, at which date the share of services in Indian GDP was 49%. By the end of the sample period in 2005, Indian GDP per capita had increased to about 8.3% of U.S. GDP per capita, and the corresponding share of services accounted for about 52% 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% of the average U.S. GDP per capita of 1980-2005, and services accounted for 38% of aggregate GDP. In 1859, the U.S. had grown to 7.3% of its average 1980-2005 GDP per capita value with the output share of services being 41%. By 1899, U.S. GDP per capita had grown to 13.5% of its average 1980-2005 GDP per capita value, and the output share of services in GDP had risen only to about 47%. 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% 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 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 who has homothetic preferences defined over goods of the three sectors which are gross substitutes. Using sectoral data, I calculate sector specific TFP growth rates which are fed exogenously into the model with the objective of examining the

[1] These data are obtained from Weiss and Gallman (1969); they report data for every 10 years starting from 1839 to 1899.

model's performance 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. With respect to sectoral employment shares, the model has difficulty in matching the data. Also, the rates of growth of sectoral employment shares predicted by the model are very close to those of sectoral output shares, a feature not observed in the data. This is a result of using the Cobb Douglas functional form. Introduction of sector specific tax policy and public capital as an additional factor of production in each sector helps to break the relationship between the growth rates of sectoral output and employment shares. It also improves the model's predictions for shares of employment in each sector which come closer to matching the data.

The three sector model described above is used in two specific applications in this paper. The first case involves a quantitative experiment conducted which highlights 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 particular deregulation and privatization of banking, business and communications services, which resulted in significant productivity improvement in this sector.

The second application involves using a modified version of the model with the objective of improving the baseline model's performance with respect to sectoral employment shares. A per unit tax is imposed on the industrial and service sectors while agriculture faces no tax[2]. The tax revenue is used to finance an aggregate stock of public capital which is distributed between the three sectors. As in Barro (1990), public capital serves as an input to private production and the conducted exercise highlights the productive role of this form of capital as well as the effect of the tax policy on labor and output reallocations across sectors. The absence of tax in agriculture reduces the relative price of the good produced by this sector while having no effect on the price of the other goods. If the goods are assumed to be substitutes, then this attracts a larger proportion of labor into agriculture. Also, government capital has an impact on sectoral labor reallocation. The sector which is more intensive in the use of government capital experiences a relatively higher growth in its output. This leads to relatively faster price decline and a larger share of labor being absorbed by this sector,

[2]The income from agricultural operations in India is exempted from income tax.

since goods are substitutes.

The process of structural change has been studied by previous authors using two classes of models. The first class of models focuses 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 focuses 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: unequal technological change across sectors coupled with non-homothetic preferences. Rogerson states that while unequal technological change can generate reallocation across industry and services, non-homothetic preferences are required to generate the reallocation of resources out of agriculture.

The rest of the paper is organized as follows: the next section contains empirical facts about sectoral output and sectoral employment in the Indian economy. The growth accounting exercise is explained in section 3. Section 4 presents a disaggregated analysis of the sub-sector activities within the service sector. 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 presents the model with public capital as an input to private production as described above. The last section concludes.

2 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%, respectively. The left panel of 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% to about 21%, the share of industry increased from 24 to 27%, while the share of services grew from 38% to 52%. 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.

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. 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 the right panel of Figure 2.

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%, whereas in industry and services, it was 19 and 29%, 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 (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.

3 Growth Accounting

3.1 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 (a), industry (i) and services (s)- for the 1980-2005 period. This exercise involves decomposing changes in 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 TFP in a sector. The details of the data are provided in the Data Appendix.

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

$$Y_{jt} = A_{jt} K_{jt}^{\nu_j} L_{jt}^{\gamma_j} N_{jt}^{1-\nu_j-\gamma_j}$$

where Y_{jt}, K_{jt}, L_{jt}, N_{jt} and A_{jt} are the value added, capital stock, land, labor and TFP in sector $j = \{a, i, s\}$ at date t, respectively. ν_j, γ_j, $(1 - \nu_j - \gamma_j)$ represent the share of rental payments to capital, share of rental payments to land, and share of wage payments to labor, in the total value added of sector j respectively. Then the growth rate of the total factor productivity growth in sector j can be estimated as

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

Land is an input to production in agriculture only; hence for $j = \{i, s\}$, γ_j=0.

There is a debate in the growth accounting literature regarding the appropriate measure of output one should use in sectoral productivity calculations. One can use value added data or gross output data, but either data can lead to different estimates of TFP growth rates. Simple algebra yields the following relationship between the TFP growth rate using gross output data ($g(A_{GO})$) and that calculated from value added data ($g(A_{VA})$)[3]

$$g(A_{GO}) = s_{VA} g(A_{VA}) \tag{2}$$

Because the share of value added in gross output is often less than unity and varies over time, TFP growth rates deduced from gross output data are often less than those calculated using

[3] See technical appendix for derivation

value added data. In other words, one can say that productivity measures based on gross output calculation are less sensitive to changes in the degree of vertical integration between industries. However one cannot completely dismiss TFP calculations based on value added data as they indicate how much extra delivery to final demand per unit of primary inputs an industry/sector generates. Also, practical aspects make value added data relatively easier to use since consistent sets of gross output measures require dealing with intra-industry flows of intermediate products, which may be difficult to estimate empirically. The OECD manual discusses yet another advantage of value added based productivity measures which can be understood in a more general setup. If technical change does not affect all factors of production symmetrically but only operates on primary inputs then the value-added based measure is the appropriate measure of technical change that one should rely on[4].

For India, sectoral gross output data are available from 2000 onwards. Growth accounting, using these data, reveals that average annual growth of TFP in agriculture, industry and services was $0.5\%, 0.6\% \& 1.4\%$, respectively during 2000-2005. However, it would be difficult to draw any inferences about productivity growth for the entire sample period using sectoral gross output data for the last five years. Instead, I use data on value added by sector which are strongly correlated (correlation +0.99) to gross output by sector. Although the productivity calculations using value added data yield different quantitative results, the qualitative result of services experiencing highest TFP growth among the three sectors remains valid.

3.2 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 Data Appendix. I refer to these as 'baseline' results.

During the 1980-2005 period, agricultural real value added grew at an average annual rate of 3.25%. The contributions of capital, labor and TFP were 18, 21 and 59%, respectively [5]. Land made a small contribution of about 2.5% during the entire period. In the pre-liberalization period, real value added was growing at 4.27%, of which TFP growth ac-

[4] Such a set-up would require that firms choose their input combinations in two stages: In the first stage, they decide how to combine value added and intermediate inputs and in the second stage, a labor/capital mix is determined to generate value added.

[5] The percentage contribution of each factor is measured as the value of the factor share multiplied by the growth rate of the factor, divided by real value added growth rate.

counted for 51%. The contribution of labor was next largest at 29%, followed by capital which accounted for 16%. Land made a small contribution of about 3%. In the post-liberalization period, growth in real value added decreased to about 2.5%; the contribution of TFP increased to account for 69% of real value added growth. Capital and labor accounted for 21 and 9% of growth, respectively, whereas the contribution of land was almost negligible at 0.6%.

In industry, real value added grew at 6.25% during the entire 1980-2005 period. The contribution of capital was the largest and measured about 53%, while that of labor was 25%. TFP made a smaller contribution of 21% during this period. In the pre-liberalization period, real value added was growing at 6.78%, to which capital made a significant contribution of 56%. The contribution made by labor was 31%, followed by TFP which accounted for only 13%. The post-liberalization period witnessed a slow down of industrial real value growth to 5.77 %. Again, the contribution of capital was largest, accounting for about 52%. TFP's role increased as its contribution was second largest, at about 25%, followed closely by labor which made a contribution of 22%.

Real value added growth in the service sector was about 7.22% for the entire period, of which TFP's contribution was dominant- 46%. Labor accounted 31% and capital's contribution stood at 23%, respectively. In the pre-liberalization period, real value added grew at 6.63%. The contributions of capital and labor were 19 and 39%, respectively, while TFP accounted for 40%. In the post-liberalization period, real value added growth increased to 7.77%. The contribution of capital increased to 24%, while that of labor decreased to 25%. TFP's contribution was marked; TFP growth alone accounted for 50% 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% respectively. Their estimates differ slightly from those reported in Table 1, probably since they do not calibrate factor shares using data but instead assume certain values for sectoral factor shares. Table 2 presents their growth rate estimates for the three sectors during the 1980-2004 period as a comparison. In their accounting exercise, they have an additional factor input - human capital- measured as education 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[6].

From Table 1 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 low in advanced economies, especially when compared to the TFP growth in the industrial sector in the data from most countries[7]. As a sensitivity check, I use other values of the sectoral factor shares and confirm the principal finding: TFP growth was highest in services during 1980-2005 and witnessed a major boost in the post-liberalization period [8].

The above analysis emphasizes the role played by services' growth in the Indian economy and compels one to look further *within* this sector to learn about the different types of services which are driving growth. I present a decomposition of the different sub-sectors within services in the next section.

4 Services: A Look Inside

4.1 Analyzing Value Added

In order to carefully examine the growth within the service sector, the top panel of Table 3 presents the decomposition of value added growth (expressed as average annual rates of change) in the different sub-sectors of services[9]. The first sub-division is retail and wholesale trade, hotels and restaurants, transport, storage and communication (THTSC), the second encompasses finance, business services, insurance and real estate (FBIR), and the third sub-division is community, social and personal services (CSP).

While the table displays growth rates for each of the three sub-groups as well as the individual sub-sectors for the entire period, the sub-group which catches the reader's attention on account of its impressive growth following liberalization is THTCS. It was growing at 6% during 1980-1990 and after 1991 its growth picked up to about 8.5%. The remarkable growth of communication services within THTSC following the 1991 reforms makes this sec-

[6] Verma (2012) incorporates sectoral human capital and finds that TFP growth rates are not very different from those obtained here.

[7] See Echevarria (1997).

[8] Results are available on the author's website http://allman.rhon.itam.mx/ rubina.verma/research.html

[9] These data have been taken from Business Beacon, Centre for Monitoring Indian Economy (CMIE).

tor stand out all by itself. Value added growth in communication increased three fold- from 6.1% in the first phase to about 18.3%- in the post liberalization phase. This tremendous growth can be attributed to the reforms carried out within the telecommunication sector, a discussion of which is carried out in Section 9. Trade, hotels and restaurants also witnessed impressive growth - the former grew from 5.9 to 7.4% while hotels and restaurants witnessed an increase from 6.5 to about 9.2% between the two phases.

The CSP sub-group saw a small rise in its growth rate from 6.1 in the pre-liberalization period to 6.3% after liberalization. Here, other services saw a rise in their growth rate, from 5.3% prior to liberalization, to about 7% following it. The second component of this sub-group, namely public administration and defense, saw a slowdown in their growth rate from about 7 to 5.5%.

While the first and third sub-groups witnessed an increase in their growth post 1991, the FBIR sub-group experienced a small decline in its growth rate- from 9.2% in the pre-liberalization phase- to about 8% following liberalization. Both, banking and insurance services, as well as real estate, dwellings, legal and business services recorded a fall in their value added growth rates. The slowdown was more pronounced in the latter than in the former. On further analysis, I find that value added in private banking and insurance services was growing at the rate of about 14% per annum between 1994 to 2004. The growth of public banking and insurance services was comparatively much smaller during the same period; value added grew at 7% each year. This could potentially explain the slowdown in the growth of banking and insurance services. While other activities like dwellings, real estate and legal services witnessed a decline in their growth rates, business services recorded enormous growth: its average annual value added growth rate during 1994-2004 was of the order of 23% [10].

There is yet another way of examining the behavior of different services within the broad umbrella of services. One can classify the services into three groups: Group I is traditional services comprising of retail and wholesale trade, transport and storage, public administration and defense. Group II consists of a hybrid between the traditional and modern services. This group includes education, health and social work, hotels and restaurants and other community, social and personal services. The third group contains modern services and examples of these are financial intermediation (banking and insurance), computer services,

[10] Refer to the working paper on author's website for details on growth rates of these activities.

business services, communications, and legal and technical services. The bottom panel of Table 3 presents growth rates of these three groups from 1980 to 2004. Value added in traditional services grew at 6.4% during the entire period, growing at about 6% during the pre-liberalization period and increasing slightly to about 6.7% following liberalization. The hybrid category of services saw a significant improvement in its growth rate from about 5.4 to 7.2%, before and following liberalization. Modern services saw marked growth in the pre-liberalization phase, of about 9%, only to increase slightly more to about 10% following liberalization. The growth rates of these groups as shares of value added in services are also presented. While the share of the first and the second group has declined throughout the period, at an average annual rate of 0.7%, the share of the third group has grown remarkably- about 2% per annum. The decline in the share of traditional services has been consistent over time. The fall in the first phase occurred at an average rate of 0.5%, and this decline became more stark in the post-liberalization phase, 0.9%. This result is consistent with the finding in Eichengreen and Gupta (2011) that growth in traditional services slowed down after 1990. Between 1980 and 1990, the share of Group II was decreasing at an average annual rate of 1.1% and, although still negative, the decline was smaller at 0.4% during the second phase. The share of modern services also recorded a small drop: Although during both the phases this group experienced positive growth in its share, in the first phase the increase was slightly higher than in the second phase, 2.1% versus 1.8%.

The finding of highest value added growth rate observed in modern services is seen in Eichengreen and Gupta (2011). These authors conduct a careful and detailed study of the evolution of the service sector in India from 1950 to 2008. Table 2 in their paper reports average annual growth in value added for the three sub-groups - traditional, hybrid and modern services- which are as described above. They find that modern services have grown the fastest among the three groups particularly post-1990, within which business services, communication and banking services displayed very rapid growth. They also report an increase in the share of hybrid services, a result which they find to be consistent with the growth experience of other high income countries.

4.2 Analyzing Productivity

This section discusses the results from growth accounting obtained in the three sub-sectors -THTCS, FBIR, CSP. The methodology used is as discussed in sub-section 3.1.

Employment, capital stock and factor income data for the sub-sectors are obtained from the same sources as described in the data appendix. Table 4 presents the results for the entire time period as well as for the pre and post liberalization period.

In the THTCS sub-sector, TFP grew at an average annual rate of 3% during 1980-2005. It was growing at an average annual rate of 2.1% in the pre-liberalization period and increased to 3.8% in period following liberalization. The contributions of capital and labor were about 25 and 35% for the entire 1980-2005 period; the largest contributor to growth was TFP- contribution of about 40%. This pattern of TFP playing a significant role is also seen when one looks at the post-liberalization period. The contributions made by capital and labor were smaller about 23 and 32% while that made by TFP was the largest-45%- and the biggest. In the pre-liberalization period, things looked slightly different as labor's contribution was the largest at about 39%, followed by TFP which accounted for 35%, and then capital which was responsible for about 26% of value added growth.

With respect to value added growth in FBIR during the entire period, TFP played a crucial role, growing at an average annual rate of about 4% and accounting for 46% of the growth in output. Capital and labor contributed about 25 and 29%, respectively. In the pre-liberalization period, the role played by TFP was striking, a growth rate of 6% per annum and a contribution of 66% to output growth. Labor's contribution followed second, accounting for about 23% while that of capital was the least, at 11%. The post-liberalization period recorded a fall in the growth rate of productivity to about 2.4%. This could be on account of the decline in value added growth in this sub-sector while the contribution of the factor inputs increased over the same time period.

Among the three sub-sectors, CSP recorded the highest TFP growth rate of about 4.1% for the entire period which explained 66% of growth in value added of this sub-sector. Contributions made by capital and labor were relatively much smaller, about 12 and 22% respectively. In the pre-liberalization period, about half of the output growth was due to growth of labor, followed by TFP which accounted for about 39%, while the residual of 11% was attributable to capital. The post-liberalization period witnessed a heightened role of productivity growth, growing at a rate of 5.5 % and contributing to about 88 % of output growth. Labor's contribution was negligible and capital accounted for 11 % of output growth. The reader may recall that in the 1991-2005 period, value added growth actually slowed down in public administration and defense while the average growth rate of other services increased (from 5.3 to 6.9 % per annum). Hence one could hypothesize the high TFP growth in the CSP as being driven by movements in other services [11].

It would be instructive to further disaggregate each of the three sub-sectors-THTSC, FBIR and CSP- and analyze the sources of productivity here; however data limitations remain a big challenge as disaggregate employment data is unavailable for the relevant time period. Given the impressive growth in value added, one could hypothesize that communication services could have been an important force driving productivity growth in THTSC, business services in FBIR and other services in CSP.

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

$$\max_{\{k_{at},n_{at},l_{at}\}} \quad p_{at}y_{at} - r_{kt}k_{at} - w_t n_{at} - R_{lt}l_{at} \quad s.t. \quad y_{at} = b_{at}k_{at}^{\theta}l_{at}^{\gamma}n_{at}^{1-\theta-\gamma}, \quad \theta+\gamma \in (0,1) \tag{3}$$

Similarly, in the industrial and the service sector, firms solve

$$\max_{\{k_{it},n_{it}\}} \quad y_{it} - r_{kt}k_{it} - w_t n_{it} \quad s.t. \quad y_{it} = b_{it}k_{it}^{\alpha}n_{it}^{1-\alpha}, \quad \alpha \in (0,1) \tag{4}$$

$$\max_{\{k_{st},n_{st}\}} \quad p_{st}y_{st} - r_{kt}k_{st} - w_t n_{st} \quad s.t. \quad y_{st} = b_{st}k_{st}^{\phi}n_{st}^{1-\phi}, \quad \phi \in (0,1) \tag{5}$$

[11] Activities such as Radio and TV broadcasting & Research and scientific services recorded very high growth rates during this period. For details refer to the author's website.

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.

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].

5.2 Preferences

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

$$U(c_{at}, c_{it}, c_{st}) = ln(\omega_a c_{at}^{\epsilon} + \omega_i c_{it}^{\epsilon} + \omega_s c_{st}^{\epsilon})^{(1/\epsilon)} \quad , \quad \epsilon < 1 \tag{9}$$

where c_j is the consumption of good j $(j = a, i, s)$ in period t, and $\sum \omega_{j=a,i,s} = 1$. The elasticity of substitution between c_a, c_i and c_s is given by $\frac{1}{1-\epsilon}$.

The household solves the following utility maximization problem

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

$$\text{s.t.} \quad p_{at}c_{at} + c_{it} + p_{st}c_{st} + k_{t+1} - (1-\delta)k_t = r_{kt}k_t + w_t + R_{lt} \quad , \forall \;\; t = 0, 1, ..\infty \tag{10}$$

with $k_0 > 0$ given, and the discount factor $\beta \in (0, 1)$.

[12]In the data, stock of agricultural land is virtually fixed and increases by less than 4 % over the 25 year time interval. In comparison, agricultural capital grows by 82 %, and labor grows by more than 100 %.

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 baseline model studied in this paper 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 [13].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). 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.

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

[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 9.

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 later); the results yield a value of the elasticity of substitution greater than one, implying that the three goods are substitutes.

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

$$\frac{k_{t+1}}{k_t} = \frac{b_{it} k_t^{\alpha-1}}{\hat{\lambda}^{\alpha}} \left[1 - \frac{x_{at} c_t}{X_t y_t} \frac{1-\theta-\gamma}{1-\alpha} \Omega_1 - \frac{x_{st} c_t}{X_t y_t} \Omega_2 \right] - \frac{c_t}{X_t k_t} + (1-\delta) \tag{11}$$

$$\frac{c_{t+1}}{c_t} = \beta \left(1 + \alpha b_{it+1} k_{t+1}^{\alpha-1} \hat{\lambda}^{\alpha-1} - \delta \right) \tag{12}$$

These equations imply that the aggregate capital-labor ratio, the aggregate consumption and the aggregate output (see Appendix A) all grow at different rates. This is because of the assumption of different sectoral factor shares and presence of a fixed input, land, in agriculture. If one relaxes these assumptions, i.e - assumes same values of factor shares and absence of land, then balanced growth can exist in this economy. Specifically, Equations (11) and (12) will now look like

$$\begin{aligned} \frac{k_{t+1}}{k_t} &= b_{it} k_t^{\alpha-1} - \frac{c_t}{k_t} + (1-\delta) \\ \frac{c_{t+1}}{c_t} &= \beta \left(1 + \alpha b_{it+1} k_{t+1}^{\alpha-1} - \delta \right) \end{aligned}$$

These are similar to equations (21) and (22) in Ngai and Pissarides (2007). This economy now displays balanced growth in which the aggregate capital-labor ratio, aggregate consumption and aggregate output (the latter two deflated by the price of manufacturing good) grow at the rate of labor augmenting technological progress in the capital good producing (manufacturing) sector.

A recent paper by Alvarez-Cuadrado and Long (2011) examines structural transformation and growth assuming non-unitary elasticity of substitution in factor inputs. In their framework, they have a final good sector and two intermediate good sectors. The final good as well as the output of sector 1 are produced using the Cobb-Douglas technology while sector 2 produces the good using non-unitary but constant elasticity of substitution between the factor inputs (CES production function). They show that as the aggregate capital-labor ratio increases in the economy, resulting in an increase in ratio of wage rate to rental rate of capital, the more flexible sector (with relatively higher elasticity of substitution of factor inputs) employs more of the relatively cheaper factor, capital, and substitutes away from the more expensive factor, labor, at a faster rate than what the less flexible sector can do. Hence, an increase in the economy wide capital-labor ratio results in a relatively higher share of capital moving to the more flexible sector and a proportionately greater share of labor entering the less flexible sector. The implications for aggregate growth are also discussed by them. In their environment, a constant growth path (CGP) which is defined as a solution along which the aggregate capital-output ratio is constant, exists only under certain assumptions. The first assumption requires that the capital shares in the production functions of sectors 1 and 2 are equal while the second assumption requires that the TFP growth rates in the two sectors are equal. On the other hand, if TFP growth rates are allowed to differ across sectors, then non balanced growth is a likely outcome in which each sector would grow at a different rate permanently.

6 Calibration

6.1 Methodology

I now assess whether the model can replicate the sectoral transformation witnessed by the Indian economy between 1980 and 2005. In particular, I evaluate the performance of the model in matching the sectoral output and employment share trends 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 % in each period. The subjective discount factor, β, is calibrated to the average Indian real interest rate during 1980-2005 (about 7 %) less the assumed rate of depreciation of capital.

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 and market clearing in sector $j = \{a, s\}$ imply

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

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 $\frac{\omega_s}{\omega_a}$. Similarly, one can obtain a value of $\frac{\omega_s}{\omega_i}$. Since the utility weights sum to 1, the individual values for these weights can be determined. In order to calibrate the initial levels of sectoral TFPs, I set $b_{i0} = 1$ in the initial period and obtain b_{a0} and b_{s0} by ensuring that $\frac{p_a y_a}{p_s y_s}$ and $\frac{y_i}{p_s y_s}$ as implied by the model are similar to those seen in the data for 1980.

The parameter values are presented in Table 5.

7 Results

The trends in sectoral output shares implied by the model and those observed in the data are presented in the top panel of Figure 3. 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 the bottom panel of Figure 3. While the model can track the industrial employment share closely, it overpredicts the level of employment share in services and underestimates the level of employment in agriculture. The inability of the model to capture the correct level of employment shares in the agricultural and service sector over the sample period is a feature of the Cobb-Douglas production function and is hard wired in the model. A detailed explanation for this is provided in the technical appendix.

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

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 the given period. The growth rates implied by the model and those calculated from the data are displayed in Table 6. The model implies that the share of agricultural output declined at an average annual rate of 2.3%. The growth rate calculated from the data is about 2.2%, 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%, which is little lower than the growth of 0.3% 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%. This share grows at an average annual rate of 1.3% in the data, and therefore the model does a good job here.

With respect to employment shares, the model generates a growth in the share of employment in the service sector of 1.4% and matches perfectly the growth seen in the data - of 1.4%. In the other two sectors, the model's predictions for the growth in these shares are similar to the growth in sectoral output shares. In the industrial sector, data suggests that the share of employment grew at a rate of 1.1%; the model generates much lower growth of 0.1% % per annum. In the agricultural sector, the model predicts the share of employment to decline at a much faster rate of 2.3%, whereas, in the data, the movement of labor is slower at 0.9%.

Figure 4 depicts the behavior of sectoral capital-output ratios from 1980 to 2005 and compares them with the data. For ease of comparison, the initial period's capital-output ratio in each sector has been normalized to one in the data as well as in the model. In the agricultural sector, the data and the model reveal a declining trend in the capital-output ratio over time, the decline in the model being faster than that seen in the data. In industry, the data show a rising trend for the time period but the model predicts the capital-output ratio to be slowly declining because industrial output grows faster than the capital stock in industry. For services, the model tracks the falling trend of the sectoral capital ratio almost perfectly as is evident from the figure. The non-constancy of the sectoral capital-output ratios in the data and in the model is a feature of the unbalanced growth of the Indian economy. A more in-depth analysis to understand the behavior of sectoral capital-output ratios is provided in the technical appendix.

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: It grew from 2.68 % before liberalization to 3.85 % following it. In the agricultural sector, TFP growth slowed from 2.19 % during 1980-1990 to 1.71 % in the 1991-2005 period. Industrial TFP growth increased from 0.86 % in the pre-liberalization period to 1.42 % 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 5 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 % during 1991-2005. The model under scenario 2 does much better, as it predicts a declining growth of 3.8 %, measuring closer (albeit, a slight overestimation) to the negative growth rate of 2.8 % 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 % in the first simulation and a slightly positive growth of 0.3 % in the second scenario. Following liberalization, industrial share of output in the economy was virtually unchanged as seen in the data and the second simulation comes closer to capturing this feature quantitatively, than the growth rate predicted under the first simulation.

In the absence of the TFP growth rate increase after liberalization, the share of service sector output increases at a rate of 0.9 %. The corresponding growth in service sector output share when I allow for TFP growth rate to increase following liberalization, is about 2.2 % in the model, and about 1.7 % 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.

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 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%. 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% of service's GDP, and about 4% of aggregate GDP. Given how small these numbers are, an export-led growth hypothesis of service sector growth is difficult to support[15].

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. During 1991-2002, the cumulative share of service sector FDI inflows in service sector GDP is 0.3% and falls to 0.2% 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 [16].

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. As stated earlier, Bosworth et al. (2007) find that TFP in services grew at an average annual rate of 3% (see Table 2). Their results indicate that the average annual growth of education as a factor of production in the service sector is small at 0.4% and accounts for 14% of service's output growth. They also report that the percentage of workers with graduate education is very small, 6% in 2004, suggesting that education cannot explain the increase in productivity and output gains in services. Verma (2012) 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

[15] 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 and 53% respectively; the share of merchandise exports in aggregate value added was about 35 and 17% respectively.

[16] Details are provided on the author's website.

(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. As stated earlier, real value added growth in private banking and insurance services was about 14% per annum while that in public sector was 7% post liberalization.

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. One can hypothesize that deregulation as well as technological progress may have promoted the rapid growth of output in a short span of time.

The phenomenal growth seen in business services has been discussed in Sub-section 4.1. 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% 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 Incorporating Public Capital

In this section, I present a simple illustration to examine the impact of a sector specific policy on labor reallocation between sectors. A per unit tax is imposed on firms in industry and services while the agricultural sector faces no tax. The tax revenue is used to finance the stock of public capital in the economy which is divided between agriculture, industry and services. Hence, one can interpret the tax as being imposed on the two modern sectors to finance the infrastructure of the traditional agricultural sector.

Firms in each sector use public capital as an input to production. The productive role of the public capital is an additional source of growth here as in Barro (1990). With this new factor of production, I examine whether the baseline model's predictions for sectoral employment shares and growth rates can be improved. For simplicity it is assumed that the fractions of the public capital are employed in constant, but different proportions by each sector, where the proportions are specified exogenously. This implies $g_{at} = \kappa_a g_t; g_{it} = \kappa_i g_t; g_{st} = \kappa_s g_t$ where $\kappa_a + \kappa_i + \kappa_s = 1$ and g_t is the per capita stock of public capital at time t. If τ_t is the fraction of output that the government collects from the modern sectors at date t, then the above discussion implies

$$g_{at} + g_{it} + g_{st} = g_t = \tau_t(y_{it} + p_{st}y_{st}) \tag{13}$$

As in Barro (1990), it is assumed that production exhibits constant returns to scale in private and public capital together, but diminishing returns in private capital separately. Hence, firms in sector j $(j = a, i, s)$ now face [17]

$$\max_{\{k_{at}, n_{at}\}} p_{at}y_{at} - r_{kt}k_{at} - w_t n_{at} \quad s.t. \quad y_{at} = b_{at}k_{at}^{\theta}g_{at}^{1-\theta}n_{at}^{1-\theta}, \quad \theta \in (0,1) \tag{14}$$

$$\max_{\{k_{it}, n_{it}\}} (1-\tau_t)y_{it} - r_{kt}k_{it} - w_t n_{it} \quad s.t. \quad y_{it} = b_{it}k_{it}^{\alpha}g_{it}^{1-\alpha}n_{it}^{1-\alpha}, \quad \alpha \in (0,1) \tag{15}$$

$$\max_{\{k_{st}, n_{st}\}} (1-\tau_t)p_{st}y_{st} - r_{kt}k_{st} - w_t n_{st} \quad s.t. \quad y_{st} = b_{st}k_{st}^{\phi}g_{st}^{1-\phi}n_{st}^{1-\phi}, \quad \phi \in (0,1) \tag{16}$$

The market clearing for the three final goods are

$$\begin{aligned} c_{at} &= y_{at} \\ c_{it} + k_{t+1} - (1-\delta)k_t &= (1-\tau_t)y_{it} \\ c_{st} &= (1-\tau_t)y_{st} \end{aligned}$$

While the market clearing condition for agriculture remains the same as in the baseline model, the introduction of a per unit tax affects industry and services. For services, consumption is now equal to the firm's post-tax output while in industry, the post tax output is used to finance consumption and investment. The consumer's utility function and his budget constraint remain unchanged as in equations (9) and (10)[18].

The employment share in services relative to that in agriculture can be expressed as

$$g\left(\frac{n_s}{n_a}\right) = g(1-\tau) + \frac{\epsilon}{1-\epsilon}\left[g\left(\frac{b_s}{b_a}\right) + g(1-\tau) + (\phi-\theta)g(k_i) - (\phi-\theta)g(g)\right] \tag{17}$$

[17] For simplicity, it is assumed that land is absent in agriculture.

[18] Since land is absent, there will be no rental income from land on the RHS of the consumer's budget constraint.

One can decompose the effect of the components of the RHS to see their individual impacts on the growth of relative employment shares $g\left(\frac{n_s}{n_a}\right)$ over time. I continue to assume that goods are substitutes in consumption $\epsilon < 1$.

1. Effect of per unit tax on relative employment growth is negative. A per unit tax reduces the relative price of agricultural good by $(1-\tau)$ while having no effect on the relative price of the service good. This induces a proportionately greater share of labor into the agricultural sector.

2. Effect of relative TFP growth, $g\left(\frac{b_s}{b_a}\right)$, on growth of relative employment is positive. An increase in the TFP growth rate of services relative to agriculture makes services relatively cheaper, thus inducing a greater fraction of labor into this sector.

3. Effect of increase in capital-labor ratio in industry (the capital good producing sector), $g(k_i)$, is positive. Since it is assumed that services have a higher intensity in the use of capital than agriculture ($\phi > \theta$), an increase in capital-labor ratio in industry has a bigger impact on services as this sector can increase its share of output by relatively more. Hence, the relative price decline of this sector's good is larger, attracting more labor into this sector. In Ngai and Pissarides (2007) growth in relative employment shares is determined solely by the relative TFP growth rates because the capital shares are assumed to be equal across sectors; hence the effect of this term is absent.

4. Effect of an increase in public capital $g(g)$ leads to a decline in the relative employment share. Since agriculture uses public capital relatively more intensively than services $(1-\theta > 1-\phi)$ by assumption, a unit increase in public capital results in relatively more output growth and consequently, relatively faster price decline in agriculture.

To assess how the share of employment in a sector producing only the consumption good changes with respect to the capital good producing sector, consider the analogous expression for share of employment in services relative to industry.

$$(18) \qquad g\left(\frac{n_s}{n_i}\right) = \frac{\epsilon}{1-\epsilon}\left[g\left(\frac{b_s}{b_i}\right) + (\phi-\alpha)g(k_i) - (\phi-\alpha)g(g)\right] + g\left(\frac{1}{1+I/c_i}\right)$$

Since both sectors are being taxed at the same rate, there is no net effect of τ_t here. The analysis of the individual components, $g\left(\frac{b_{st}}{b_{it}}\right)$, $(\phi-\alpha)g(k_i)$, $(\phi-\alpha)g(g)$ parallels that as discussed above. The new term that warrants explanation is $g\left(\frac{1}{1+I/c_i}\right)$; this term reflects the additional employment needed in industry to produce the capital good. As the ratio of investment to consumption increases in the industrial sector, the demand for labor will rise, hence inducing a relatively greater fraction of labor into this sector.

10.1 A Numerical Example

In order to assess the quantitative implications of including public capital as an input to production, I present a numerical illustration. In this exercise, I use the same parameter values and sectoral TFP growth rates [19] as in the baseline case (Table 5). The new parameters are $\tau_t, \kappa_a, \kappa_i$ and κ_s. For simplicity, I assume that the tax rate does not vary over time, i.e. $\tau_t = \tau$. The parameter τ can be thought of as a measure of the basic corporate tax rate which has been in the range of 0.5-0.3 for the 1980-2005 period. The values of $\kappa_j, j = \{a, i, s\}$ have been chosen so as to get a close fit of model generated sectoral employment shares to the data values in the initial period. These imply values of $\kappa_a = 0.25, \kappa_i = 0.45, \kappa_s = 0.25$. If one has to interpret these shares as the share of public services, and not as the share of public capital stock being used in each sector then measuring these is a challenging task, given the unavailability of data on sectoral public services. Moreover, a complete time series on public sector capital stock by sectors is available for a limited time period (1994 onwards).

Figure 6 displays the trends in sectoral output and employment. One observes that the model's predictions for sectoral output shares compare closely to those seen in the baseline case, and also track the trends in the data very closely. The more relevant change is observed in the model's predictions for sectoral employment shares. In the first year, the share of labor employed in agriculture has increased from 38 (baseline model) to about 55 % thus fairing better in matching the data. In the service sector as well, the performance of the model improves significantly from the baseline case; it now allocates a smaller share of labor to this sector in the initial year, 27 %, as compared to the baseline prediction of 42 % in 1980. The share of labor being allocated to industry decreases slightly to about 18 % from its baseline prediction of 20 % in 1980, and thus comes closer to matching the data value of 15 % in 1980.

The bottom panel of Table 6 documents the rates of change in shares of sectoral output and employment over time. The most visible change is seen in agriculture. The rate of decline in agricultural output is now 1.9 %, lower than baseline case of 2.3 % but still

[19] The initial sectoral TFP levels have been recomputed to match the model generated output shares in 1980; TFP growth rate in agriculture is 1.67% as it excludes land as a factor input to conform with the current framework.

a close match to the decreasing growth rate seen in the data (-2.2 %). Labor's movement out of the agricultural sector has slowed down considerably. In the data the decline is of the order of 1 %; in the modified model labor share in agriculture declines at an average annual rate of about 1.6 %, much slower than the 2.3 % observed in the baseline case. In industry, the growth of the share of output is slightly negative at about -0.24 % while the growth rate of employment share stands at 0.13 %. In the service sector, the growth of the share of output is about 1.6 % while employment growth is slightly faster at about 2 %. The slightly negative growth of industry can be explained as follows. Public capital and private capital are complimentary inputs; by allocating 45 % of public capital to industry, the share of private capital being allocated to this sector in the initial year is also high. Recall that the industrial good witnesses slowest decline in its price on account of slowest TFP growth and consequently is demanded the least by the household. Therefore, after the initial year this sector starts to release both labor and capital to the relatively more efficient service sector. However, the industrial sector is also the sector where the private capital good is being produced. Consequently, overtime the demand for private capital from services pushes industry to produce more of the private capital good. Once this stage is reached, resources start to move into industry and one observes a turnaround in the growth of industrial output share. The growth rate of industrial output is negative during 1980-2005, because even though industrial output starts to grow after the first few periods, its share (27.2 %) in 2005 is slightly lower than the share in 1980 (28.8 %). If one would calculate the growth rate after 2005, then a positive growth rate would be obtained. Also, a lower value of κ_i would imply that the turnaround in the share of industrial output would occur at a earlier stage [20].

As discussed in the section above (equation 17), on account of relatively higher TFP growth and higher intensity in the use of private capital, services attract relatively more labor than agriculture. These two factors more than offset the relative larger impact of the growth of government capital on agriculture than on services (since $1 - \theta = 0.78 > 1 - \phi = 0.63$). Since the tax rate is assumed to be non varying, the effect of changing taxes is absent in the numerical example. If the tax rate is allowed to be decreasing (increasing) overtime then the demand for labor by the agrarian sector would decrease (increase) overtime since the fall in relative price would be slower (faster). Comparing industry with services, we see

[20] Results have been omitted due to brevity.

that relatively larger TFP growth and higher intensity of using government capital ($1 - \phi = 0.63 > 1 - \alpha = 0.49$) have a relatively larger impact on generating higher employment growth in services, offsetting the impact of labor movement into industry on account of higher intensity of private capital. The second term on the right hand side of equation (18) is the factor responsible for attracting labor into industry -in order to produce the capital good. Clearly, this force is important to understand the changing nature of the growth pattern seen in industry, as has been discussed above.

The main contribution of the inclusion of government capital in the model is seen by the fact that for any sector, the growth rates of the shares of output produced and labor employed are no longer numerically same - a problem seen in the baseline version of the model. Moreover, it better replicates the evolution of sectoral employment shares, without a deterioration in its ability to capture the behavior of sectoral output shares. The numerical example is an exercise designed to highlight the role of government policy in affecting output and sectoral reallocations in the Indian case. A rigorous and thorough calibration would entail measuring sectoral TFP growth rates, sectoral factor shares, the public and private capital in each sector according to the described set up. This is an interesting area for future research but remains a challenge given the unavailability of data as well as the appropriate measurement of public services used by each sector.

11 Conclusion

This paper examines the factors responsible for generating the services led growth witnessed in the Indian economy during 1980-2005. Results from growth accounting show that changes in total factor productivity (TFP) were important, and that TFP growth was the largest source of service sector value added growth. As compared to the other sectors, 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. I build 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. In order to highlight the importance of the post liberalization increase in service sector TFP, a simple exercise which shows a significant improvement in the model's performance when one takes into account the post-1991 TFP growth rate is conducted. I argue that the increase in service sector TFP was a result of the liberalization policies adopted by India.

The results indicate that while the baseline model performs well in its prediction of sectoral value added shares and their growth rates, it cannot quantitatively match the levels of sectoral employment seen in the data. It predicts the growth of sectoral employment shares to be very similar to the growth of sectoral output shares, a feature not seen in the data. This limitation arises due to use of the Cobb-Douglas production functional form. One of the later sections of this paper presents an augmented version of the baseline model which incorporates public capital as an input to private production. The main contribution of public capital is seen by the fact that the sectoral employment shares generated by the model match the trends in the data. Also, the growth rates of the shares of output and labor employed in each sector are no longer numerically equivalent. This exercise thus highlights the role of government policy in influencing India's structural transformation.

Data Appendix

All the data described below- Real GDP, capital stock, employment, land, factor income- have been computed by considering both the formal (organized) and the informal (unorganized) segments[21] of the Indian economy.

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. Further 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)[22].

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 fixed capital formation series. The depreciation rate is assumed to be constant at 5 % 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. These data are constructed with the help of annualized growth rates of sectoral employment reported by Gupta (2002)[23].

Land: An estimate of land used in the agricultural sector is needed. Data series on

[21] Most of the estimates of the informal/unorganized segments are provided by the National Sample Survey Organisation Round Surveys and Reports.

[22] 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.

[23] Details of the cds approach are provided in this report.

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) [24].

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,[25] 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.

[24] 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.

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

Derivation-Relationship between GO and VA TFP Growth rates

To understand how sectoral TFP growth rates computed using value added data differ from those derived by using gross output data, it is instructive to see the relationship mathematically. I continue using the Cobb-Douglas production function form and for ease, the sector (j) and time subscripts (t) will be dropped. This implies that

$$g(A_{VA}) = g(Y_{VA}) - \nu_{VA}^{k} g(K) - \nu_{VA}^{n} g(N) \tag{19}$$

where g denotes growth rate, VA signifies value added and $\nu_{VA}^{k} + \nu_{VA}^{n} = \frac{rK}{Y_{VA}} + \frac{wN}{Y_{VA}} = 1$. If one uses sectoral gross output then the production function will look like

$$Y = AK^{\nu_{GO}^{k}} N^{\nu_{GO}^{n}} M^{\nu_{GO}^{m}} \tag{20}$$

where $\nu_{GO}^{k}, \nu_{GO}^{n}$, and ν_{GO}^{m} are the shares of rental payments to capital, wage payments to labor and the share of intermediate inputs in the gross output (GO) of the sector, respectively. Then equation (20) yields

$$g(A_{GO}) = g(Y_{GO}) - \nu_{GO}^{k} g(K) - \nu_{GO}^{n} g(N) - \nu_{GO}^{m} g(M) \tag{21}$$

Equation (19) can also be expressed as

$$g(A_{VA}) = g(Y_{VA}) - \frac{\nu_{GO}^{k}}{s_{VA}} g(K) - \frac{\nu_{GO}^{n}}{s_{VA}} g(N) \tag{22}$$

where s_{VA} is the share of value added in the gross output of a sector. Since $VA = GO - M$, differentiating with respect to time yields the following relationship

$$g(Y_{VA}) = \frac{1}{s_{VA}} \left(g(Y_{GO}) - \nu_{GO}^{m} g(M) \right) \tag{23}$$

Then, equations (21), (22) and (23) imply

$$g(A_{GO}) = s_{VA} g(A_{VA}) \tag{24}$$

Solving the Model

Firms

At time t, using the firms' first order conditions and the assumption that capital and labor are completely mobile across sectors, one gets [26]

$$r_{kt} = p_{at}\theta b_{at} k_{at}^{\theta-1} n_{at}^{-\gamma} = \alpha b_{it} k_{it}^{\alpha-1} = p_{st}\phi b_{st} k_{st}^{\phi-1}$$

[26] Here k_j is the capital-labor ratio in sector $j = \{a, i, s\}$.

$$w_t = p_{at}(1-\theta-\gamma)b_{at}k_{at}^{\theta}n_{at}^{-\gamma} = (1-\alpha)b_{it}k_{it}^{\alpha} = p_{st}(1-\phi)b_{st}k_{st}^{\phi}$$

$$R_{lt} = p_{at}\gamma b_{at}k_{at}^{\theta}n_{at}^{1-\gamma}$$

Since $\frac{w_t}{r_{kt}}$ is equal across the three sectors, one obtains the following relation

$$\frac{w_t}{r_{kt}} = \frac{1-\theta-\gamma}{\theta}k_{at} = \frac{1-\alpha}{\alpha}k_{it} = \frac{1-\phi}{\phi}k_{st} \tag{25}$$

which implies

$$k_{at} = \frac{\theta}{1-\theta-\gamma}\frac{1-\alpha}{\alpha}k_{it} \tag{26}$$

$$k_{st} = \frac{\phi}{1-\phi}\frac{1-\alpha}{\alpha}k_{it} \tag{27}$$

The equality of the marginal product of capital across sectors implies

$$p_{st} = \frac{\alpha}{\phi}\frac{b_{it}}{b_{st}}\frac{k_{it}^{\alpha-1}}{k_{st}^{\phi-1}}$$

which can be further simplified, after substituting value of k_{st} from above, into

$$p_{st} = \left(\frac{\alpha}{\phi}\right)^{\phi}\left(\frac{1-\phi}{1-\alpha}\right)^{\phi-1}\frac{b_{it}}{b_{st}}k_{it}^{\alpha-\phi} \tag{28}$$

Also, from the equality of the marginal product of capital, one gets

$$p_{at} = \frac{\alpha}{\theta}\frac{b_{it}}{b_{at}}\frac{k_{it}^{\alpha-1}}{k_{at}^{\theta-1}}n_{at}^{\gamma}$$

which can be further simplified, after substituting value of k_{at} from above, into

$$p_{at} = \left(\frac{\alpha}{\theta}\right)^{\theta}\left(\frac{1-\theta-\gamma}{1-\alpha}\right)^{\theta-1}\frac{b_{it}}{b_{at}}k_{it}^{\alpha-\theta}n_{at}^{\gamma} \tag{29}$$

Household

At time t, the household's intra-temporal optimization between c_{at}, c_{st} and c_{it} imply

$$c_{at} = \left(\frac{\omega_i p_{at}}{\omega_a}\right)^{\left(\frac{1}{\epsilon-1}\right)} c_{it} \tag{30}$$

$$c_{st} = \left(\frac{\omega_i p_{st}}{\omega_s}\right)^{\left(\frac{1}{\epsilon-1}\right)} c_{it} \tag{31}$$

$$c_{st} = \left(\frac{\omega_a p_{st}}{\omega_s p_{at}}\right)^{\left(\frac{1}{\epsilon-1}\right)} c_{at} \tag{32}$$

And the inter-temporal Euler equation is

$$\left(\frac{c_{it+1}}{c_{it}}\right)^{\epsilon-1}\frac{C_t}{C_{t+1}} = \frac{1}{\beta(1+r_{kt+1}-\delta)}$$

where C_t is defined for convenience as $(\omega_a c_{at}^{\epsilon} + \omega_i c_{it}^{\epsilon} + \omega_s c_{st}^{\epsilon})$.

At any time t, the inter-temporal Euler equation, the intra-temporal optimization equation between c_{st} and c_{at} and the resource constraint of the industrial sector are used to solve for three endogenous variables k_{it+1}, n_{at} and n_{it}. Once these are determined, n_{st} is determined as $n_{st} = 1 - n_{at} - n_{it}$, k_{at}, k_{st} are determined from equations (26) and (27), p_{at}, p_{st} are obtained from equations (29) and (28), y_{at}, y_{it}, y_{st} are determined from equations of the production functions, c_{at}, c_{st} are known from the resource constraints and c_{it} is known from the household's intra-temporal optimization condition between c_{at} and c_{it}.

Characterization of Unbalanced Growth

The aggregate capital-labor ratio can be expressed as

$$k_t = k_{at}n_{at} + k_{it}n_{it} + k_{st}n_{st}$$

Since $k_{at} = \frac{\theta}{1-\theta-\gamma}\frac{1-\alpha}{\alpha}k_{it} = \lambda_a k_{it}$ and $k_{st} = \frac{\phi}{1-\phi}\frac{1-\alpha}{\alpha}k_{it} = \lambda_s k_{it}$, the aggregate capital-labor ratio can be re-written as

$$k_t = \hat{\lambda}k_{it} \quad \forall \ t = 1....\infty \tag{33}$$

where $\hat{\lambda} = \frac{\theta}{1-\theta-\gamma}\frac{1-\alpha}{\alpha}n_{at} + n_{it} + \frac{\phi}{1-\phi}\frac{1-\alpha}{\alpha}n_{st}$ The resource constraint in the industrial sector can be expressed as

$$b_{it}k_{it}^{\alpha}n_{it} = c_{it} + k_{t+1} - (1-\delta)k_t$$

Using equation (33), the above can be re-written as

$$\frac{k_{t+1}}{k_t} = \frac{b_{it}n_{it}k_t^{\alpha-1}}{\hat{\lambda^{\alpha}}} - \frac{c_{it}}{k_t} + (1-\delta) \tag{34}$$

Now, consider the aggregate per capita consumption expenditure, c

$$c_t = p_{at}c_{at} + c_{it} + p_{st}c_{st}$$

Dividing through by c_{it}, this can be expressed as

$$c_t = c_{it}X_t$$

where $X_t = x_{at} + x_{st} + 1$, $x_{at} = \frac{p_{at}c_{at}}{c_{it}}$ and $x_{st} = \frac{p_{st}c_{st}}{c_{it}}$
Similarly, the aggregate per capita output y_t is

$$y_t = p_{at}y_{at} + y_{it} + p_{st}y_{st} \tag{35}$$

Using the expressions for p_{at} from (29), p_{st} from (28), the expressions for the production functions, and equations (26), (27) imply after some algebraic simplification

$$y_t = b_{it}k_{it}^{\alpha}\left[\frac{1-\alpha}{1-\theta-\gamma}n_{at} + n_{it} + \frac{1-\alpha}{1-\phi}n_{st}\right]$$

which can be expressed as

$$y_t = b_{it}k_{it}^{\alpha}\Omega_1 \tag{36}$$

where $\Omega_1 = \left[\frac{1-\alpha}{1-\theta-\gamma}n_{at} + n_{it} + \frac{1-\alpha}{1-\phi}n_{st}\right]$

Now, profit maximization implies $n_{at} = \frac{(1-\theta-\gamma)p_{at}y_{at}}{w_t} = \frac{(1-\theta-\gamma)p_{at}y_{at}n_{it}}{(1-\alpha)y_{it}}$. Using the resource constraint for the agriculture good and $p_{at}c_{at} = x_{at}c_{it} = \frac{x_{at}c_t}{X_t}$, one can derive the following expression for n_{at}

$$n_{at} = \frac{x_{at}c_t}{X_t b_{it}k_{it}^{\alpha}}\frac{1-\theta-\gamma}{1-\alpha}$$

Using (36), the above can be written as

$$n_{at} = \frac{x_{at}c_t}{X_t y_t}\frac{1-\theta-\gamma}{1-\alpha}\Omega_1$$

In a similar manner, one can derive the expression for n_{st} as

$$n_{st} = \frac{x_{st}c_t}{X_t y_t}\Omega_2$$

where $\Omega_2 = \left[\frac{1-\phi}{1-\theta-\gamma}n_{at} + \frac{1-\phi}{1-\alpha}n_{it} + n_{st}\right]$
Then $n_{it} = 1 - n_{at} - n_{st}$ can be expressed as

$$n_{it} = 1 - \frac{x_{at}c_t}{X_t y_t}\frac{1-\theta-\gamma}{1-\alpha}\Omega_1 - \frac{x_{st}c_t}{X_t y_t}\Omega_2$$

Therefore, equation (34) can be expressed as

$$\frac{k_{t+1}}{k_t} = \frac{b_{it}k_t^{\alpha-1}}{\hat{\lambda}^{\alpha}}\left[1 - \frac{x_{at}c_t}{X_t y_t}\frac{1-\theta-\gamma}{1-\alpha}\Omega_1 - \frac{x_{st}c_t}{X_t y_t}\Omega_2\right] - \frac{c_t}{X_t k_t} + (1-\delta) \tag{37}$$

Next, consider the utility function

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

Define $\psi_t(\cdot) = (\omega_a c_{at}^{\epsilon} + \omega_i c_{it}^{\epsilon} + \omega_s c_{st}^{\epsilon})^{(1/\epsilon)}$

The Euler equation implies

$$u_{it} = u_{it+1}\beta(1 + r_{kt+1} - \delta) \tag{38}$$

[27] Now

$$u_{it} = \frac{1}{\psi_t(\cdot)}\psi_{it}$$

$$\psi_{it} = \omega_i \left(\frac{\psi_t}{c_{it}}\right)^{(1-\epsilon)} \tag{39}$$

[28] $\psi_t(\cdot)$ is homogeneous of degree one. Then, using the Euler's theorem one can express

$$\psi_t(\cdot) = \psi_{at}c_{at} + \psi_{it}c_{it} + \psi_{st}c_{st}$$

Note that

$$\frac{u_{at}}{u_{it}} = \frac{\psi_{at}}{\psi_{it}} = p_{at}$$

This implies $\psi_{at} = p_{at}\psi_{it}$. Similarly $\psi_{st} = p_{st}\psi_{it}$. Therefore $\psi_t = (p_{at}c_{at} + c_{it} + p_{st}c_{st})\psi_{it}$ or $\psi_t = c_t\psi_{it}$. Using this in equation (39), one gets $\psi_{it} = \omega_i(\frac{c_t\psi_{it}}{c_{it}})^{(1-\epsilon)}$. But $c_t = c_{it}X_t$ which implies $\psi_{it} = {\omega_i}^{1/\epsilon}X_t^{\frac{1-\epsilon}{\epsilon}}$.

Hence, equation (38) can be written as

$$\frac{1}{c_t} = \frac{1}{c_{t+1}}\beta(1 + r_{kt+1} - \delta)$$

Using $r_{kt+1} = \alpha b_{it+1}k_{it+1}^{\alpha-1}$, one arrives at

$$\frac{c_{t+1}}{c_t} = \beta\left(1 + \alpha b_{it+1}k_{t+1}^{\alpha-1}\hat{\lambda}^{\alpha-1} - \delta\right) \tag{40}$$

[27] u_{it} is the time t marginal utility of consumption with respect to the industrial good.

[28] ψ_{it} is the time t derivate of $\psi_t(\cdot)$ with respect to the industrial good.

Explaining the Behavior of Sectoral Employment Shares

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 (and 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[29]; hence the level and the growth rate of sectoral output measure closely to the level and the growth rate of sectoral employment.

Sectoral Capital Output Ratios

One can understand the behavior of the sectoral capital-output ratios with the help of the following expressions obtained from the firm's first order condition

$$\begin{aligned}
\frac{K_{at}}{Y_{at}} &= \frac{\theta p_{at}}{r_{kt}} = \left(\frac{\theta}{\alpha}\right)^{1-\theta} \left(\frac{1-\alpha}{1-\theta-\gamma}\right)^{1-\theta} \frac{1}{b_{at}} k_{it}^{1-\theta} n_{at}^{\gamma} \\
\frac{K_{it}}{Y_{it}} &= \frac{\alpha}{r_{kt}} = \frac{k_{it}^{1-\alpha}}{b_{it}} \\
\frac{K_{st}}{Y_{st}} &= \frac{\phi p_{st}}{r_{kt}} = \left(\frac{\phi}{\alpha}\right)^{1-\phi} \left(\frac{1-\alpha}{1-\phi}\right)^{1-\phi} \frac{1}{b_{st}} k_{it}^{1-\phi}
\end{aligned}$$

Taking logs of the above expressions and differentiating with respect to time yields

$$\begin{aligned}
g\left(\frac{K_a}{Y_a}\right) &= (1-\theta) g(k_i) - g(b_a) + \gamma g(n_a) \\
g\left(\frac{K_i}{Y_i}\right) &= (1-\alpha) g(k_i) - g(b_i) \\
g\left(\frac{K_s}{Y_s}\right) &= (1-\phi) g(k_i) - g(b_s)
\end{aligned}$$

[29] 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

Thus, long run movements of sectoral capital-output ratios are largely driven by differences in the sectoral factor shares (θ, α, ϕ) and sectoral TFP growth rates. Moreover, the growth rate of the capital-labor ratio in industry, $g(k_i)$ is not constant over time, a feature of non balanced growth. In comparison, in Ngai and Pissarides (2007) the factor shares are equal across sectors (and land is absent), differences in sectoral capital-output ratios are driven by differences in the sectoral TFP growth rates, while the growth of capital-labor ratio in industry is constant [30].

Derivation - Government Capital

The firm's first order conditions with respect to capital and labor imply

$$r_{kt} = p_{at}\theta b_{at}k_{at}^{\theta-1}g_{at}^{1-\theta} = (1-\tau_t)\alpha b_{it}k_{it}^{\alpha-1}g_{it}^{1-\alpha} = (1-\tau_t)p_{st}\phi b_{st}k_{st}^{\phi-1}g_{st}^{1-\phi}$$

$$w_t = p_{at}(1-\theta)b_{at}k_{at}^{\theta}g_{at}^{1-\theta} = (1-\tau_t)(1-\alpha)b_{it}k_{it}^{\alpha}g_{it}^{1-\alpha} = (1-\tau_t)p_{st}(1-\phi)b_{st}k_{st}^{\phi}g_{st}^{1-\phi}$$

Since $\frac{w_t}{r_{kt}}$ is equal across the three sectors, one can solve for the optimal capital-labor ratio in agriculture and services

$$k_{at} = \frac{\theta}{1-\theta}\frac{1-\alpha}{\alpha}k_{it}; \quad k_{st} = \frac{\phi}{1-\phi}\frac{1-\alpha}{\alpha}k_{it}$$

The equality of the marginal product of capital across sectors implies

$$\begin{aligned} p_{st} &= \frac{\alpha}{\phi}\frac{b_{it}}{b_{st}}\frac{k_{it}^{\alpha-1}}{k_{st}^{\phi-1}}\frac{g_{it}^{1-\alpha}}{g_{st}^{1-\phi}} \\ p_{at} &= (1-\tau_t)\frac{\alpha}{\theta}\frac{b_{it}}{b_{at}}\frac{k_{it}^{\alpha-1}}{k_{at}^{\theta-1}}\frac{g_{it}^{1-\alpha}}{g_{at}^{1-\theta}} \end{aligned}$$

which can be simplified further after substituting the values of $k_{st}\&k_{at}$ from above

$$\begin{aligned} p_{st} &= \left(\frac{\alpha}{\phi}\right)^{\phi}\left(\frac{1-\phi}{1-\alpha}\right)^{\phi-1}\frac{b_{it}}{b_{st}}\frac{g_{it}^{1-\alpha}}{g_{st}^{1-\phi}}k_{it}^{\alpha-\phi} \\ p_{at} &= (1-\tau_t)\left(\frac{\alpha}{\theta}\right)^{\theta}\left(\frac{1-\theta}{1-\alpha}\right)^{\theta-1}\frac{b_{it}}{b_{at}}\frac{g_{it}^{1-\alpha}}{g_{at}^{1-\theta}}k_{it}^{\alpha-\theta} \end{aligned}$$

From the firms' first order conditions, one gets

$$\frac{wn_{st}}{wn_{at}} = \frac{(1-\tau_t)(1-\phi)p_{st}y_{st}}{(1-\theta)p_{at}y_{at}} \tag{41}$$

[30] It grows at the same rate as the aggregate capital-labor ratio, the rate of labor augmenting technological progress in the manufacturing sector.

which can be simplified using the resource constraints in services and agriculture

$$\frac{n_{st}}{n_{at}} = \frac{(1-\tau_t)(1-\phi)}{(1-\theta)} \frac{p_{st}c_{st}}{p_{at}c_{at}} \tag{42}$$

Recall that the household's intra-temporal optimization between consumption of agriculture and services (the sectors in which output produced is consumed completely) is given by

$$c_{st} = \left(\frac{\omega_a p_{st}}{\omega_s p_{at}}\right)^{\left(\frac{1}{\epsilon-1}\right)} c_{at}$$

$\Rightarrow$

$$\frac{p_{st}c_{st}}{p_{at}c_{at}} = \left(\frac{\omega_a}{\omega_s}\right)^{\frac{1}{\epsilon-1}} \left(\frac{p_{st}}{p_{at}}\right)^{\frac{\epsilon}{\epsilon-1}}$$

Substituting the expressions for $p_{at}, p_{st}, g_{at} \& g_{st}$ from above and simplifying one gets

(43)

$$\frac{p_{st}c_{st}}{p_{at}c_{at}} = \left(\frac{\omega_s}{\omega_a}\right)^{\frac{1}{1-\epsilon}} \left(\left(\frac{\alpha}{1-\alpha}\right)^{\phi-\theta} \left(\frac{1-\alpha}{1-\phi}\right)^{1-\phi} \left(\frac{1-\theta}{1-\alpha}\right)^{1-\theta} \frac{\theta^\theta}{\phi^\phi} \frac{b_{at}}{b_{st}} \frac{\kappa_a^{1-\theta}}{\kappa_s^{1-\phi}} \left(\frac{g}{k_{it}}\right)^{\phi-\theta} \frac{1}{1-\tau_t}\right)^{\frac{-\epsilon}{1-\epsilon}}$$

Combining (42) and (43), taking logs and differentiating over time results in:

$$g\left(\frac{n_s}{n_a}\right) = g(1-\tau) + \frac{\epsilon}{1-\epsilon}\left[g\left(\frac{b_s}{b_a}\right) + g(1-\tau) + (\phi-\theta)g(k_i) - (\phi-\theta)g(g)\right]$$

Consider the analogous expression for employment share in agriculture relative to that in industry.

$$\frac{n_{st}}{n_{it}} = \frac{(1-\phi)}{(1-\alpha)} \frac{y_{it}}{p_{st}y_{st}} \tag{44}$$

Using the resource constraint for industry, one can express this as

$$\frac{n_{st}}{n_{it}} = \frac{1-\phi}{1-\alpha}\left(\frac{p_{st}c_{st}}{c_{it}} \frac{1}{(1+I_t/c_{it})}\right) \tag{45}$$

where $I_t = k_{t+1} - (1-\delta)k_t$. Using the intra-temporal optimization condition between consumption of services and industry gives

$$\frac{n_{st}}{n_{it}} = \left(\frac{\omega_s}{\omega_i}\right)^{\frac{1}{1-\epsilon}} \left(\left(\frac{\alpha}{\phi}\right)^{\phi} \left(\frac{1-\phi}{1-\alpha}\right)^{\phi} \frac{b_{it}}{b_{st}} \frac{\kappa_i^{1-\alpha}}{\kappa_s^{1-\phi}} \left(\frac{g}{k_{it}}\right)^{\phi-\alpha}\right)^{\frac{-\epsilon}{1-\epsilon}} \left(\frac{1}{1+I_t/c_{it}}\right) \tag{46}$$

Taking logs and differentiating (46) with respect to time results in:

$$g\left(\frac{n_s}{n_i}\right) = \frac{\epsilon}{1-\epsilon}\left[g\left(\frac{b_s}{b_i}\right) + (\phi-\alpha)g(k_i) - (\phi-\alpha)g(g)\right] + g\left(\frac{1}{1+I/c_i}\right)$$

Numerical Algorithm

This section describes the numerical algorithm used to simulate the model. The model is simulated for $T = 50$ periods [31]. The solution technique involves solving three equations, the inter-temporal Euler equation, the intra-temporal optimization equations between c_{st} and c_{at} and the resource constraint of the industrial sector, for t=1 to T-1 periods.

$$\left(\frac{c_{it+1}(b_{at+1}, b_{it+1}, k_{it+1}, n_{at+1})}{c_{it}(b_{at}, b_{it}, k_{it}, n_{at})}\right)^{\epsilon-1} \frac{C_t(b_{at}, b_{it}, b_{st}, k_{it}, n_{at}, n_{it})}{C_{t+1}(b_{at+1}, b_{it+1}, b_{st+1}, k_{it+1}, n_{at+1}, n_{it+1})} = \frac{1}{\beta(1 + r_{kt+1}(k_{it+1}) - \delta)}$$

$$c_{st}(b_{st}, k_{it}, n_{at}, n_{it}) = \left(\frac{\omega_a}{\omega_s}\right)^{\left(\frac{1}{\epsilon-1}\right)} c_{at}(b_{at}, k_{it}, n_{at}) \left(\frac{p_{st}(b_{it}, b_{st}, k_{it})}{p_{at}(b_{at}, b_{it}, k_{it}, n_{at})}\right)^{\left(\frac{1}{\epsilon-1}\right)}$$

$$c_{it}(b_{at}, b_{it}, k_{it}, n_{at}) + k_{t+1}(k_{it+1}, n_{at+1}, n_{it+1}) - (1-\delta)k_t(k_{it}, n_{at}, n_{it}) = y_{it}(b_{it}, k_{it}, n_{it})$$

The objective is to determine the time paths of k_i, n_a and n_i, using the system of equations specified above. To initialize the algorithm, I guess a path for k_i, n_a and n_i, i.e. $\{k_{it}\}_{t=1}^{T}, \{n_{at}\}_{t=1}^{T}, \{n_{it}\}_{t=1}^{T}$. At any time t, the endogenous variables are: k_{it+1}, n_{at} and n_{it}, given k_t and exogenous paths of sectoral TFPs. Then, I use the solutions of the above equations to update the time t values of the vectors: $\{k_i\}$, $\{n_a\}$ and $\{n_i\}$. This process is carried out for $t = 1, \ldots, T-1$ and in the end I get the updated time paths. I compare these vectors with those of the starting guesses and check if the difference between the two is smaller than a defined threshold value. If the difference exceeds the threshold, the guess is replaced by the new paths. This process is repeated until the error becomes smaller than the threshold criterion.

[31] I report results obtained by simulating the model for 50 periods, but these results are similar to those obtained when the model is simulated for 100 periods.

References

Acemoglu, Daron and Veronica Guerrieri, "Capital Deepening and Non-Balanced Economic Growth," *Journal of Political Economy*, June 2008, *116* (3), 467–498.

Alvarez-Cuadrado, F. and N.V. Long, "Capital-Labor Substitution, Structural Change and Growth," *McGill University Working Paper*, 2011.

Banerjee, Abhijit, "The Paradox of Indian Growth: A Comment on Kochar et al," *Journal of Monetary Economics*, July 2006, *53*, 1021–1026.

Banga, Rashmi, "Critical Issues in India's Services-led Growth," *India Resident Mission Policy Brief Number 2*, 2006.

Barro, Robert J., "Government Spending in a Simple Model of Endogeneous Growth," *Journal of Political Economy*, October 1990, *98* (5 (II)), S103–S125.

Baumol, W.J., "Macroeconomics of Unbalanced Growth: The Anatomy of an Urban Crisis," *The American Economic Review*, 1967, *57*, 415–426.

Bhattacharya, B.B. and S. Sakthivel, "Economic Reforms and Jobless Growth in India in the 1990s," *Institute of Economic Growth, Working Paper No. 245*, 2004.

Bosworth, Barry, Susan M. Collins, and Arvind Virmani, "Sources of Growth in the Indian Economy," *NBER Working Paper 12901*, February 2007.

Center for Monitoring Indian Economy Private Ltd., Bombay, "Business Beacon Version 2.0," 2005.

Central Statistical Organisation, Ministry of Planning and Programme Implementation, New Delhi, Government of India, " National Accounts Statistics," 2008.

Dekle, Robert and Guillaume Vandenbroucke, "A Quantitative Analysis of China's Structural Transformation," *Working Paper*, September 2009.

Echevarria, Cristina, "Changes in Sectoral Composition Associated with Economic Growth," *International Economic Review*, 1997, *38* (2).

Eichengreen, Barry and Poonam Gupta, "The Service Sector as India's Road to Economic Growth," *NBER Working Paper Series*, 2011, (16757).

Falvey, R. and N. Gemmell, "Are Services Income-Elastic? Some New Evidence," *Review of Income and Wealth*, September 1996, *42* (3).

Gollin, Douglas, "Getting Income Shares Right," *Journal of Political Economy*, 2002, *110* (2).

Gordon, Jim and Poonam Gupta, "Understanding India's Services Revolution," *IMF Working Paper, WP/04/171*, 2004.

Gupta, S. P., "Report of the Special Group on Targeting Ten Million Employment Opportunities per year over the Tenth Plan Period," *Government of India, Planning Commission*, 2002.

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

Ministry of Planning and Programme Implementation, Department of Statistics and Programme Implementation, "Brochure on New Series on National Accounts Statistics, Base Year 1993-94," 1999.

Munshi, Kaivan and Mark Rosenzweig, "Why is Mobility in India so Low? Social Insurance, Inequality, and Growth," *BREAD Working Paper 092*, 2004.

Ngai, Rachel and Christopher A. Pissarides, "Structural Change in a Multi-Sector Model of Growth," *The American Economic Review*, 2007, *97* (1).

Organisation for Economic Co-Operation and Development, "Measuring Productivity: Measurement of Aggregate and Industry-Level Productivity Growth," 2001.

Panagariya, Arvind, "India's Trade Reform: Progress, Impact and Future Strategy," 2004.

_ , "Transforming India," 2006.

Rodrik, Dani and Arvind Subramanian, "From Hindu Growth to Productivity Surge: The Mystery of the Indian Growth Transition," *NBER Working Paper 10376*, March 2004.

Rogerson, Richard, "Structural Transformation and the Deterioration of European Labor Market Outcomes," *Journal of Political Economy*, 2008, *116*, 235–259.

Singh, Nirvikar, "Services-Led Industrialization in India: Assessments and Lessons," *MPRA Paper 1273, University Library of Munich, Germany*, August 2006.

_ **and T.N. Srinivasan**, "Indian Federalism, Economic Reform and Globalization," *Public Economics*, September 2004, (0412007).

Sivasubramonian, S, *The Sources of Economic Growth in India 1950-1 to 1999-2000*, Oxford University Press, 2004.

Verma, Rubina, *Structural Transformation and Jobless Growth in the Indian Economy-The Oxford Handbook of the Indian Economy*, Vol. forthcoming, Oxford University Press, 2012.

Weiss, Thomas and Robert Gallman, "The Service Industries in the Nineteenth Century," *Studies in Income and Wealth, NBER*, 1969, *34.*

World Bank Report, "Trade Policies in South Asia: An Overview," *Report No. 29949*, 2004.

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)	(22.5)
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)	(45.5)
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 Estimates: Bosworth, Collins & Virmani (2007)

Sector/Period	Annual Percentage Rate of Change			Contribution of			
	Output	Employment	Output per Worker	Physical Capital	Land	Education	TFP
Agriculture							
capital=0.5, land=0.25							
1980-04	2.8	1	1.8	0.5	-0.1	0.3	1.1
1983-93	2.9	1.4	1.5	0.2	-0.1	0.2	1.2
1999-04	1.8	1	0.8	0.9	-0.2	0.4	-0.1
Industry							
capital=0.4							
1980-04	6.4	3.5	2.9	1.6		0.3	1
1983-93	6	2.9	3.1	1.3		0.3	1.4
1999-04	6.4	5.5	0.9	-0.1		0.2	0.9
Services							
capital=0.4							
1980-04	7.6	3.6	4	0.7		0.4	2.9
1983-93	6.5	3.8	2.7	0.3		0.4	2
1999-04	7.8	3.5	4.4	0.9		0.4	3.1

Table 3: Real Value Added Growth in Services' Sub-Sectors (%)

Sub-Sectors	Entire period 1980-2005	Pre liberalization 1980-1990	Post liberalization 1991-2005
THTCS	**7.3**	**5.9**	**8.5**
Trade (retail and wholesale)	6.7	5.9	7.4
Hotels & Restaurants	7.9	6.5	9.2
Railways	4.3	4.4	4.1
Transport by other means	6.6	6.3	7.1
Storage	1.9	2.6	1.1
Communication	12.5	6.1	18.3
FBIR	**8.5**	**9.2**	**8.0**
Banking & Insurance	10.3	11.4	9.9
Real estate, Ownerships of dwellings			
Legal & Business services	7.1	7.9	6.4
CSP	**6.1**	**6.1**	**6.3**
Public administration & Defense	5.9	7.0	5.5
Other services	6.2	5.3	6.9
Value Added			
Group I	6.4	6.1	6.7

Group II	6.4	5.4	7.2
Group III	9.3	8.9	9.7
Share in Services' Value Added			
Group I	-0.7	-0.5	-0.9
Group II	-0.7	-1.1	-0.4
Group III	2.0	2.1	1.8

Table 4: Growth Accounting-Services' Sub-Sectors

	THTCS	**FBIR**	**CSP**
Factor share			
capital	0.42	0.53	0.14
labor	0.58	0.47	0.86
Decomposition of average annual changes in real value added (%)			
Entire period 1980-2005			
Growth in real value added	7.3	8.5	6.1
due to capital	1.8	2.1	0.7
	(24.9)	(25.2)	(11.5)
due to labor	2.5	2.4	1.3
	(34.5)	(28.7)	(22.0)
due to TFP	**3.0**	**3.9**	**4.1**
	(40.6)	(46.1)	(66.5)
Pre liberalization 1980-1990			
Growth in real value added	5.9	9.2	6.1
due to capital	1.5	1.0	0.7
	(26.3)	(11.3)	(11.5)
due to labor	2.3	2.1	3.0
	(38.6)	(22.7)	(49.2)
due to TFP	**2.1**	**6.1**	**2.4**
	(35.2)	(66.0)	(39.3)
Post liberalization 1991-2005			
Growth in real value added	8.5	8.0	6.3
due to capital	2.0	2.9	0.7
	(23.1)	(36.3)	(11.4)
due to labor	2.7	2.7	0.04
	(32.3)	(33.7)	(0.6)
due to TFP	**3.8**	**2.4**	**5.5**
	(44.5)	(30.0)	(88.0)

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

Table 5: Calibrated Parameters

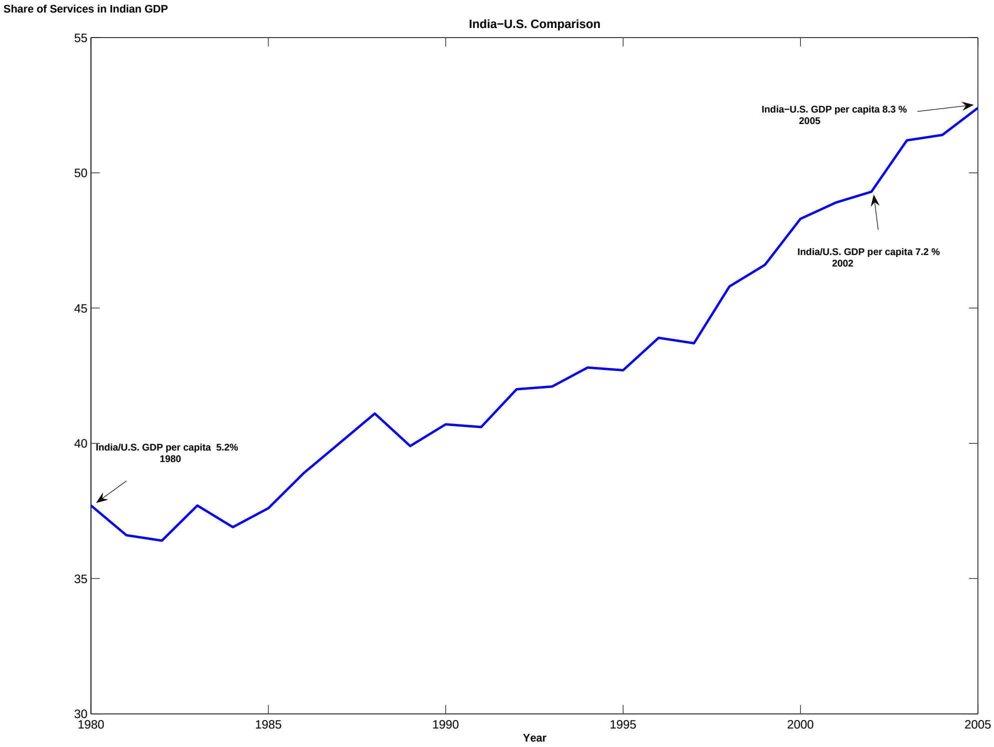
Parameters	**Description**	**Values**
θ	capital share in agriculture	0.22
γ	land share in agriculture	0.2
α	capital share in industry	0.51
ϕ	capital share in services	0.37
b_{a0}	initial TFP level in agriculture	5.2514
b_{i0}	initial TFP level in industry	1
b_{s0}	initial TFP level in services	2.5749
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 6: Average Annual Growth Rates (%), 1980-2005

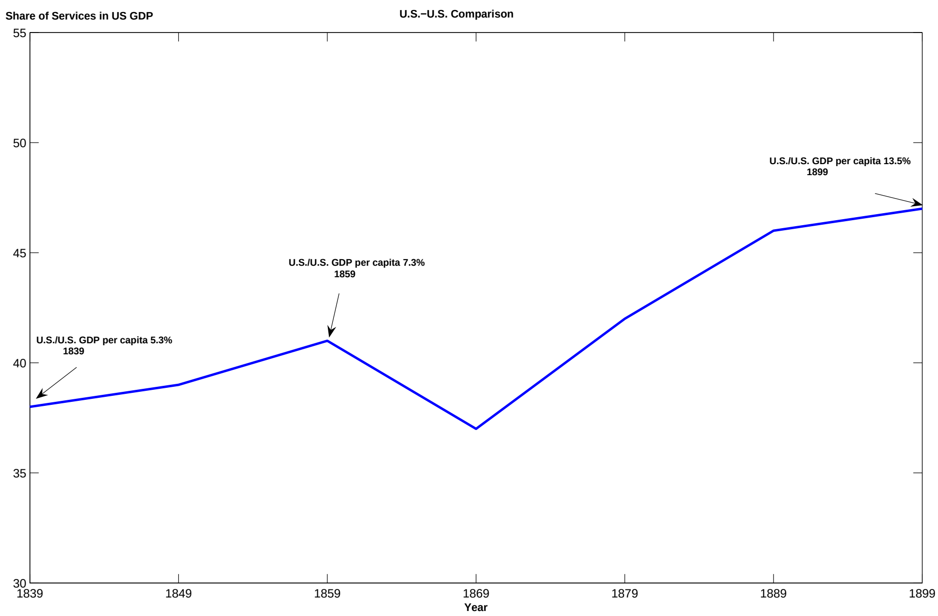
Variable	**Data**	**Model**
Baseline Model		
Share of output in agriculture	-2.2	-2.3
Share of output in industry	0.3	0.1
Share of output in services	1.3	1.4
Share of employment in agriculture	-0.9	-2.3
Share of employment in industry	1.1	0.1
Share of employment in services	1.4	1.4
Model with Public Capital		
Share of output in agriculture	-2.2	-1.9
Share of output in industry	0.3	-0.24
Share of output in services	1.3	1.6
Share of employment in agriculture	-0.9	-1.6
Share of employment in industry	1.1	0.13
Share of employment in services	1.4	2.0

Table 7: Average Annual Growth Rates (%), 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



(a)



(b)

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

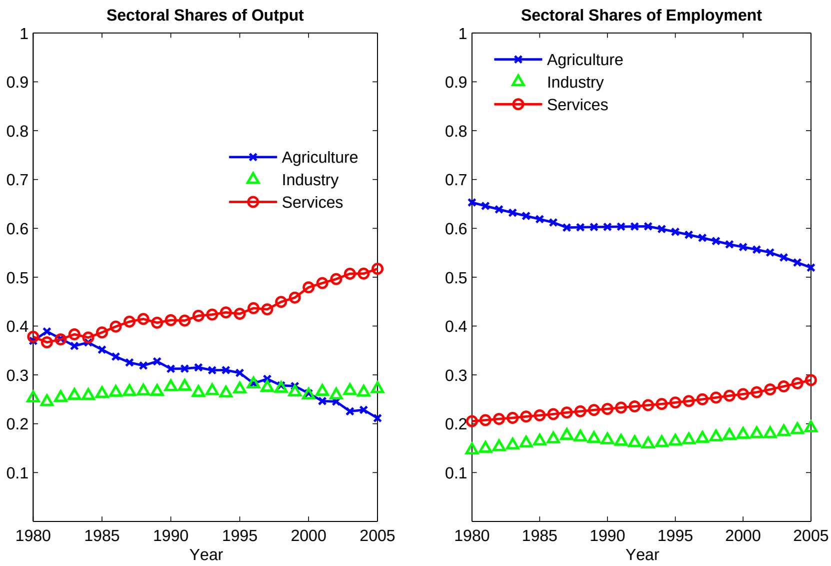


Figure 2:
Sectoral Shares of Output and Employment: Data

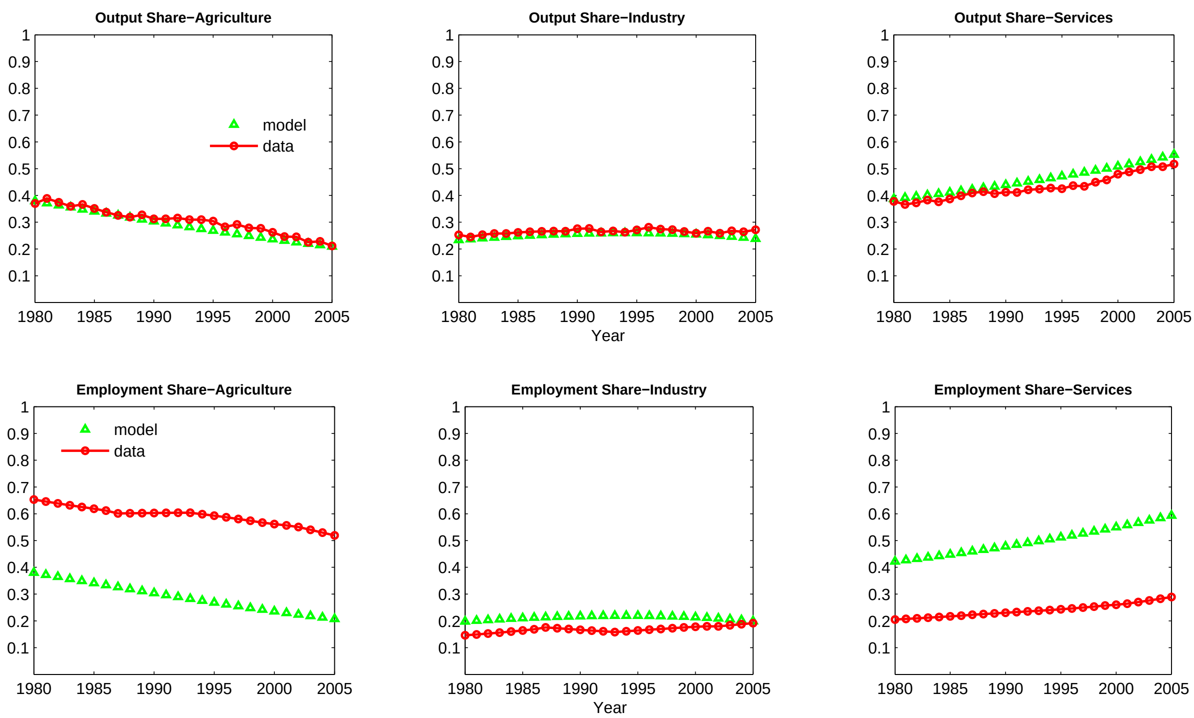


Figure 3:
Sectoral Shares of Output and Employment: Baseline Results

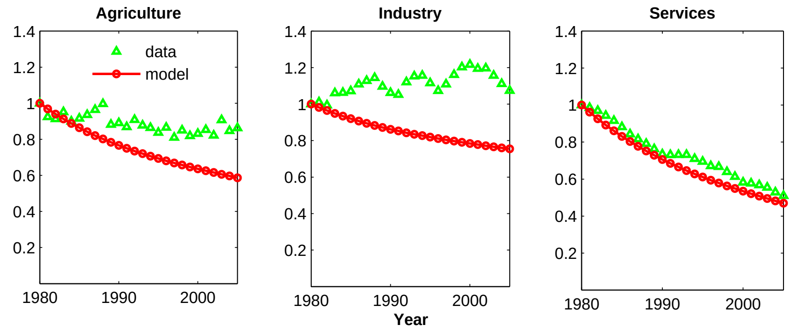


Figure 4:
Sectoral Capital-Output Ratios:Data and Baseline Model

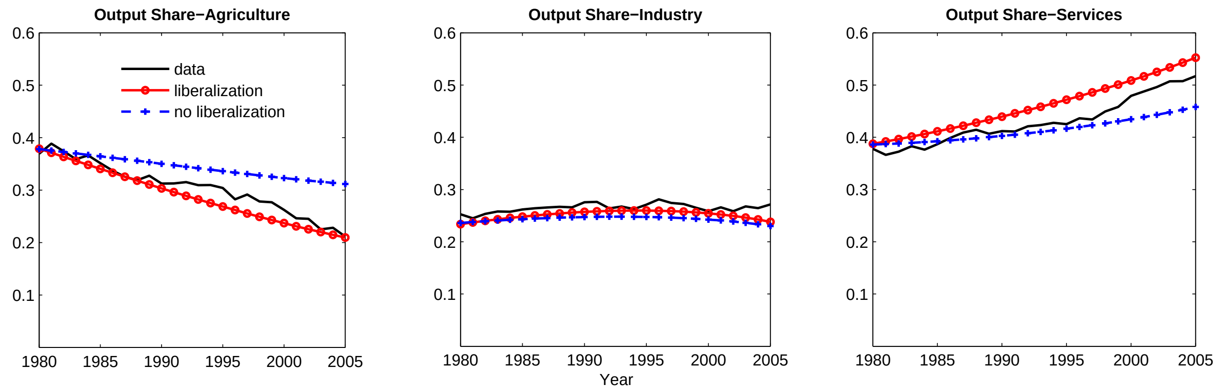


Figure 5:
Effect of Liberalization - Sectoral Shares of Output

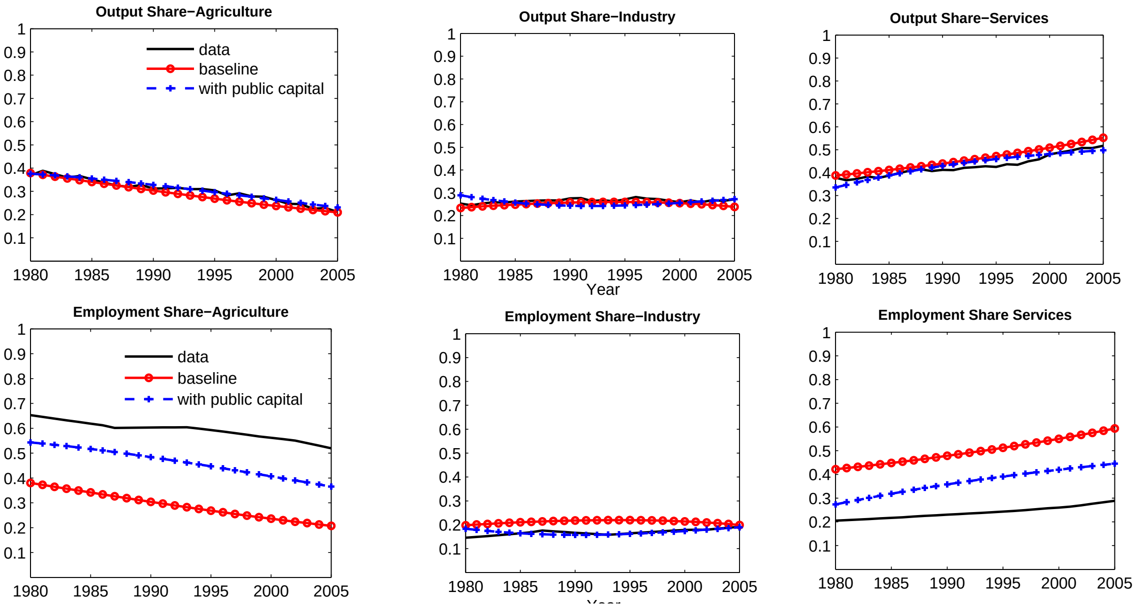


Figure 6:

Sectoral Shares of Output and Employment: With Public Capital