A macroeconomic analysis of the sources of economic growth in India

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A MACROECONOMIC ANALYSIS OF THE SOURCES OF ECONOMIC GROWTH IN INDIA

BY

SOHINI SAHU

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A MACROECONOMIC ANALYSIS OF THE SOURCES OF ECONOMIC GROWTH IN INDIA

BY

SOHINI SAHU

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For

My parents:
Sikha Sahu
Puspendu Bikash Sahu
&
My brother:
Sayak Sahu
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ABSTRACT

Economic liberalization in 1991 marked a significant turning point for India since its independence in 1947. After decades of slow growth, the economy suddenly took off at a steady and fast pace after 1991. We investigate the factors that propelled India’s long-term economic growth and short-run economic cycles pre and post 1991. Using a multi-sector dynamic general equilibrium model specifically tailored for transition economies, we find that service sector productivity, coupled with a structural shift in the economy, have been the drivers of the recent spate of growth in India. In the period 1960-1980, productivity fluctuations in the agricultural sector were the dominant source of cycles. Since then, productivity fluctuations in the manufacturing and service sectors have been important. In the quest for the source of increasing service productivity, we use a monopolistic competition model with heterogenous firms and find that improved factor allocation across service firms have helped accelerate productivity in this sector. Since reforms in 1991 were heavily leaned towards the service sector, we also investigate the impact of liberalization and labor regulations on service firms’ economic performance. Using an unbalanced panel dataset for service sector firms, we find mixed evidence of the impacts of liberalization. Firms which were technologically superior prior to reforms, outperformed their technologically backward counterparts after liberalization. No strong evidence between firm performance and state-specific labor regulations are found in the context of service sector firms in India.
1 Introduction

When old words die out on the tongue,
new melodies break forth from the heart;
and where old tracks are lost,
a new country is revealed with its wonders.

- RABINDRANATH TAGORE

In the last century, India was born twice.

At the stroke of midnight on 14 August 1947, the British Raj in India came to an end. With the birth of a free nation, post-colonial India embarked on the task of nation building. Despite good intentions of the architects of the nation, India became a victim of self-defeating policies. In an attempt to achieve self reliance, the country shut itself out from the rest of the world. To prevent accumulation of wealth in few hands, state monopolies in key sectors were established and private entrepreneurs were restricted to specific areas of business. India had to bear the brunt of misplaced policies which resulted in the notorious “Hindu rate of growth” of 3.5 percent prior to the eighties.

Based on modest reforms towards the end of 1970s, India registered a growth rate of 5.6 percent during the decade of eighties. But this growth rate was unsustainable because it was based on excessive borrowing which plunged India into a severe financial crisis in 1991. Prompted by the crisis, sweeping economic reforms were undertaken which led to the rebirth of India in 1991. Ever since, India has grown at an average rate of 7 – 8 percent each year and has made its presence felt in the global economic scene.
India’s growth trajectory is intriguing since the economy laid dormant for over three decades before taking off suddenly and steadily. This dissertation is an attempt to look at the recent economic performance of India through the lens of macroeconomics.

Chapter 2 of this dissertation is “Transition Accounting for India in a Multi-sector Dynamic General Equilibrium Model”. Using a quantitative methodology designed specifically for emerging economies, we measure the components of India’s economic growth over the period 1960-2005. Our approach accounts for time-varying parameters, transitional dynamics and non-linear trends. We find that increased productivity in the service sector, facilitated by a structural shift toward services, is the principal driver of India’s economic growth. Our measures also suggest that the allocation of inputs across sectors has not improved over this period, and in the case of labor appears to have significantly worsened. We further find that fluctuations in output around its trend are due primarily to fluctuations in sector-specific total factor productivity, with fluctuations in labor market distortions and labor taxes also playing important roles. In the period 1960-1980, productivity fluctuations in the agricultural sector are the dominant source of cycles. Since then, productivity fluctuations in the manufacturing and service sectors have been more important.

Thus, India has seen service sector-led growth in recent years. High growth in total factor productivity (TFP) is the dominant source of growth in this sector. But what triggered this high productivity in India’s service sector? Chapter 3, “Source of Service Sector TFP Growth in India- Evidence from Micro Data”, tries to answer the above question. We use micro data on service sector companies to quantify the
effects of resource misallocation on TFP levels after the 1991 economic reforms in India. It is found that post reforms, the extent of resource misallocation has reduced in the service sector. Due to improved resource allocation, the information-technology industry operated at 84 percent of its efficient TFP level in 2005. The communication industry and community services industry registered the fastest growth in terms of moving towards their efficient TFP levels.

As evident from Chapters 2 and 3, the service sector has played a significant role toward’s India’s current growth. Economic reforms in this sector coupled with institutional changes, have enhanced the performance of the service sector. Finally, Chapter 4 of this dissertation, “Liberalization and Service Sector Performance in India”, analyzes the relationship between liberalization, service sector performance, technological capabilities of service firms and labor regulations in India between 1991 and 2005. Two measures of reforms are considered for this purpose. First, higher entry of new firms indicates reduction in entry barriers and hence is a proxy for reforms. Second, the services policy reform index captures the varying degree of reforms within industries in the post-liberalization period. We see firms closer to their technology frontier outperforming those far below the frontier in the post-entry years. Increased entry and reforms have a positive impact on frontier-firms’ economic performance and a negative impact on non-frontier firm’s performance. Contrary to the strong correlation between labor laws and performance of the manufacturing units in India, no significant relation between labor regulation and service liberalization is found.
2 Transition Accounting for India in a Multi-sector Dynamic General Equilibrium Model

2.1 Introduction

The post-colonial history of the Indian economy is a study in contrasts. In the first three decades following its independence in 1947, India’s real per capita output grew at the anemic rate of 1.6 percent per year. This dormant period was followed by a series of reforms, beginning in the early 1980s. Since then, the Indian economy has grown rapidly, with per capita output increasing 6 to 7 percent per year, and services replacing agriculture as the dominant sector.

In this paper we construct and implement a quantitative accounting procedure to measure the components of India’s economic growth. Following the business cycle accounting (BCA) procedure developed by Chari, Kehoe and McGrattan (2007; also see Mulligan, 2005), we interpret the data through the lens of a dynamic general equilibrium model. This allows us to calculate a series of “wedges”, which capture frictions or policies that alter the economy’s equilibrium dynamics. Chari et al.’s (2007) equivalence results show that many types of frictions can be expressed in terms of these wedges. Consistent with Lahiri and Yi (2006, 2008), we use a multi-sector model to calculate three types of wedges: sector-specific efficiency wedges, which are modelled as productivity shifters; allocation wedges, which are modelled as sector-
specific taxes on capital or labor; and fiscal policy wedges, which are modelled as aggregate labor income taxes, aggregate capital income taxes, or government spending shocks.

We depart from the existing literature, however, in that our accounting methodology is tailored for emerging economies. Our approach allows for non-linear trends; it recognizes that India’s economy is transitioning to, rather than residing on, a balanced growth path; and it allows for time-varying parameters that capture sectoral shifts.\(^1\) These features lead us to label our approach “transition accounting”.\(^2\)

The Indian economy provides a compelling setting to apply our methodology. Prior to the 1980s, the Indian economy was characterized by the notorious “Hindu rate of growth”. Import-substituting industrial policies sustained state monopolies in “core sectors”. To prevent the concentration of wealth, small-scale industries were protected by a combination of quota, licensing and permits. To encourage self-reliance, foreign capital and foreign technology were shunned. The reallocation of labor across sectors was restricted. All these policies led to low productivity, lost competitiveness and inefficient resource use. (Williamson and Zagha, 2002.)

In late 1970s, the second oil shock caused India’s terms of trade to worsen. The conditions attached to the resulting IMF loans led to the “pro-business” reforms that began the second phase of economic growth in the 1980s. Controls over capacity utilization and capital imports were relaxed, price controls in key industrial products

\(^{1}\)Although sectoral shifts are a feature of developed economies as well, they are considered central to the process of development.

\(^{2}\)In the approach most similar to ours, Lahiri and Yi (2006) find non-linear transition paths for a deterministic, constant-parameter economy. Verma (2008) solves a constant-parameter model that generates sectoral shifts through unbalanced growth; her analysis, however, considers only the effects of productivity growth.
like cement and aluminium were dismantled, and investment in infrastructure doubled the growth rate of the public sector. The central government’s fiscal deficit rose, however, reaching 8.5 percent of GDP in 1986-87 and depleting foreign reserves. These macroeconomic imbalances made the economy vulnerable to shocks, and finally the high oil prices caused by the first Gulf War in 1991, along with domestic political instabilities, pushed the country to the verge of defaulting on its external loans. In lieu of help from IMF, in 1991 India started “pro-market” reforms, consisting of currency devaluation, fiscal contraction and public sector divestment, financial sector and tax system reform, and the liberalization of domestic investment and foreign capital inflows. Ever since, per capita real GDP has grown 6 to 7 percent per year. The resulting sectoral changes have been just as compelling. Beginning in the 1980s, India transformed itself from a predominantly agrarian economy to one that was service-sector-based. (Williamson and Zagha, 2002; Rodrik and Subramanian, 2004.)

While it is unanimous that the right kind of policies accelerated growth in the Indian economy, the transmission channels through which these policies affected the various sectors have yet to be captured in a unified framework. Rodrik and Subramanian (2004) and Virmani (2004) corroborate the findings of Bai and Perron (1998, 2003) that a structural break occurred in the economy around 1980 from a variety of sources. They, along with Panagariya (2006), conclude that the policy shifts in the early 1980s induced large productivity responses because India was far from its production frontier.

A number of studies have argued that the manufacturing sector experienced a surge in productivity, which in turn led to a rise in aggregate productivity (Ahluwalia,
1995; and Unel, 2003). On the other hand, the IT sector is considered to be the most prominent channel of India’s growth since the 1990s (Singh, 2004). Conducting traditional growth accounting exercises, Bosworth, Collins and Virmani (2007) and Bosworth and Collins (2008) also conclude that post-1980 growth is largely due to an increase in service sector productivity. Chakraborty (2006) uses BCA to measure the productivity, investment, and labor supply shocks behind India’s growth since 1982. She finds that TFP shocks were the “primary conduit” through which India’s policy reforms stimulated its economy. Using a multi-sector accounting framework, Lahiri and Yi (2006, 2008) identify the wedges that explain why the state of Maharashtra grew so much more quickly than West Bengal. Verma (2008) uses a multi-sector model to study the rapid growth of India’s service sector.

To extend these results, we use our approach to estimate the Indian economy’s long-term, non-linear trend, and its fluctuations around this trend. We find that over the period 1960-2005, India’s trend growth is due largely to higher service sector productivity; if the service sector had not become more productive, output in 2005 would be about half its actual level. This increase in service productivity, however, was facilitated by a structural shift that increased the importance of services to aggregate output. Without this shift, output in 2005 would have been 23 percent lower. Our findings are consistent with the argument that India’s policy reforms benefited the economy primarily by allowing it to operate more efficiently. Nonetheless “direct” changes in fiscal policy also contributed; if tax rates and government spending remained at their 1960 levels, output would have been 26 percent lower. In contrast, the improved intersectoral allocation of capital had very little effect, and the inter-
sectoral allocation of labor actually worsened over the sample period—India’s service sector appears to be facing a shortage of labor. Although this apparent shortage may reflect conceptual measurement problems, if real it will pose a barrier to India’s continued economic development.

Turning to business cycles, we find that fluctuations in output around its trend are due primarily to fluctuations in sector-specific total factor productivity, with fluctuations in labor market distortions and labor taxes also playing important roles. In the period 1960-1980, prior to the reforms, productivity fluctuations in the agriculture sector were the dominant source of cycles. Since then, productivity fluctuations in the manufacturing and service sectors have been more important, with fluctuations in service-sector productivity being the largest single source of volatility.

The rest of the paper proceeds as follows. Section 2.2 develops our multi-sector model. Section 2.3 describes how we measure and parameterize the model’s wedges and time-varying parameters. Section 2.4 discusses the solutions to the model’s trend and business cycle components. Section 2.5 discusses the data we use for our analyses. Sections 2.6 and 2.7 present the analyses of the India’s trend growth and business cycle fluctuations, respectively. Section 2.8 concludes.

2.2 The Model

2.2.1 Firms

Consider a closed economy with four sectors of production—a final goods sector and three intermediate goods sectors: agriculture (a), manufacturing (m), and
services ($s$). The production technologies for intermediate goods are given by the following Cobb-Douglas production functions:

\[
Y_a = A_a K_a^\alpha L_a^{1-\alpha}, \quad (1a)
\]

\[
Y_m = A_m K_m^\mu L_m^{1-\mu}, \quad (1b)
\]

\[
Y_s = A_s K_s^\sigma L_s^{1-\sigma}, \quad (1c)
\]

where: $Y_j$ denotes total output of good $j = a, m, s$; $K_j$ ($j = a, m, s$) denotes capital inputs in sector $j$; $L_j$ denotes labor inputs; and $A_j$ are exogenous and stochastic productivity shifters. All of these variables can vary over time; in the interest of notational simplicity, we will suppress time subscripts whenever possible.

The three intermediate goods are combined in a Cobb-Douglas aggregator to produce a single non-traded final good, $Y$:

\[
Y = A_f Y_a^{\psi} Y_m^{\eta} Y_s^{\theta}, \quad (2)
\]

\[
\theta = 1 - \psi - \eta.
\]

To account for structural change, the share parameters $\psi$, $\eta$ and $\theta$ can vary over time.
Each sector is populated by perfectly competitive firms, which maximize profits:

$$\Pi_a = p_a Y_a - w_a L_a - r K_a,$$

$$\Pi_m = p_m Y_m - w_m L_m - r K_m + r \frac{\kappa_m}{1 + \kappa_m} K_m,$$

$$\Pi_s = p_s Y_s - w_s L_s - r K_s + r \frac{\kappa_s}{1 + \kappa_s} K_s,$$

$$\Pi = pY - p_a Y_a - p_m Y_m - p_s Y_s,$$

where $w_j, r$ and $p_j$ are real wages, rental rates and prices, respectively, in the $j^{th}$ sector; final goods are the numeraire, so that $p = 1$. Following Lahiri and Yi (2008), we introduce the parameters $\kappa_m$ and $\kappa_s$ to capture market frictions, adjustment costs, and other factors that might alter the allocation of capital: although we formally model $\kappa_m$ and $\kappa_s$ as subsidies/taxes, we follow Chari et al. (2007) and Mulligan (2005) and interpret them as “wedges” that can embody a wide range of frictions. We normalize $\kappa_a$ to zero, so that we are looking only at sectoral misallocations. In this light, positive values of $\kappa_m$ and $\kappa_s$ imply that the frictions divert capital to the manufacturing and service sectors. To capture sector-specific frictions in labor markets, we allow wages to vary across sectors, and introduce sector-specific taxes in the consumer’s budget constraint.\(^3\)

\(^3\)We model capital and labor frictions in different ways only to facilitate our derivations; in the end the frictions’ algebraic (as well as economic) effects are completely symmetric.
The first order conditions for the final goods sector are

\[ p\psi Y = p_a Y_a, \quad (3a) \]
\[ p\eta Y = p_m Y_m, \quad (3b) \]
\[ p\theta Y = p_s Y_s. \quad (3c) \]

Combining these conditions with the first order conditions for intermediate goods producers (see Appendix) yields:

\[ \psi(1 - \alpha) \frac{Y}{L_a} = w_a, \quad (4a) \]
\[ \eta(1 - \mu) \frac{Y}{L_m} = w_m, \quad (4b) \]
\[ \theta(1 - \sigma) \frac{Y}{L_s} = w_s, \quad (4c) \]

for labor inputs, and

\[ \alpha\psi \frac{Y}{K_a} = r, \quad (5a) \]
\[ \eta\mu \frac{Y}{K_m} = r \frac{1}{1 + \kappa_m}, \quad (5b) \]
\[ \theta\sigma \frac{Y}{K_s} = r \frac{1}{1 + \kappa_s}, \quad (5c) \]

for capital.

2.2.2 Households

The representative family receives utility from consumption and leisure. The flow
utility function for a family of size $N$ is:

$$u(C_t, L_t, N_t) = N_t \left[ \ln(C_t/N_t) - \chi \frac{(L_t/N_t)^{1+\gamma}}{1 + \gamma} \right],$$

where $C$ is consumption, $L$ is the labor supply, $\chi$ is the weight on leisure in the utility function and $\gamma$ is the inverse of the intertemporal elasticity of substitution for labor. In contrast to the production technologies, we assume that preferences are constant over time.

The family faces the following budget constraint

$$C_t + (1 + \tau_{kt})K_{t+1} = (1 - \tau_{at})w_{at}L_{at} + (1 - \tau_{mt})w_{mt}L_{mt} + (1 - \tau_{st})w_{st}L_{st} + [1 + r - \delta_t]K_t + \Pi_t + \Pi_{at} + \Pi_{mt} + \Pi_{st} + Tr_t,$$

where $K$ is the total capital stock and $\delta$ is the depreciation rate. As above, $w_i$ is the wage in sector $i$, $r$ is the interest rate and $\Pi_t$, $\Pi_{at}$, $\Pi_{mt}$ and $\Pi_{st}$ are dividends from firms. As with the capital frictions, the tax rates $\tau_{kt}$, $\tau_{at}$, $\tau_{mt}$, $\tau_{st}$ can be interpreted literally, or as wedges that embody all market frictions.\textsuperscript{4} $Tr_t$ denotes government transfers. As with capital, it is useful to express the sector-specific labor tax rates as the product of an aggregate rate and two sector-specific effects. This allows us to

\textsuperscript{4}To facilitate our analysis of the model’s trends, our treatment of capital taxes—taxes are levied on capital itself—differs from the canonical BCA approach (Chari et al., 2007), where taxes are levied on investment.
rewrite the budget constraint as

$$C_t + (1 + \tau_{kt})K_{t+1} = (1 - \tau_{lt})[w_{at}L_{at} + (1 + \ell_{mt})w_{mt}L_{mt} + (1 + \ell_{st})w_{st}L_{st}]$$

$$+ [1 + r_t - \delta_t] K_t + \Pi_t + \Pi_{at} + \Pi_{mt} + \Pi_{st} + Tr_t,$$

$$1 + \ell_{mt} \equiv \frac{1 - \tau_{mt}}{1 - \tau_{lt}}; \quad 1 + \ell_{st} \equiv \frac{1 - \tau_{st}}{1 - \tau_{lt}}; \quad \ell_{at} \equiv 0 \Leftrightarrow \tau_{lt} = \tau_{at}.$$

Positive values of $\ell_m$ and $\ell_s$ imply that labor in these sectors is “taxed” less heavily, so that frictions promote the reallocation of labor to the manufacturing and service sectors. It also bears noting, however, that if labor is measured as raw employment, $\ell_m$ and $\ell_s$ will reflect differences in skill and utilization across sectors.

In addition to the budget constraint, the family faces the time endowment constraint

$$L_t = L_{at} + L_{mt} + L_{st},$$

and the standard boundary conditions.

The first order conditions for the family’s problem are

$$\frac{N_t}{C_t} = \beta E_t \left( \frac{N_{t+1}}{C_{t+1}} \right) \frac{1}{1 + \tau_{kt}}, \quad (6)$$

$$w_{at} = w_{mt}(1 + \ell_{mt}) = w_{st}(1 + \ell_{st}) = \frac{\chi}{1 - \tau_{lt}} \left( \frac{C_t}{N_t} \right) \left( \frac{L_t}{N_t} \right)^\gamma. \quad (7)$$

Equation (6) is the inter-temporal Euler equation determining savings, with $E_t(\cdot)$ denoting expectations based on time-$t$ information. Equation (7) describes the optimal labor-leisure allocation.
2.2.3 The Government

Finally, there is a government, collecting taxes and purchasing goods and services. The government also makes lump-sum transfers, which are set to balance its budget:

\[ \tau_{al} w_{at} L_{at} + \tau_{mt} w_{mt} L_{mt} + \tau_{st} w_{st} L_{st} + \tau_{kl} K_{t+1} = G_t + Tr_t + r_t \frac{\kappa_m}{1 + \kappa_m} K_m + r_t \frac{\kappa_s}{1 + \kappa_s} K_s, \]

where \( G_t \) denotes government purchases. Government purchases have no effect on production or on household utility.\(^5\)

2.2.4 Aggregation

Let \( \kappa \) denote the average capital market distortion:

\[ \kappa = \frac{1}{\zeta} [\eta \mu \kappa_m + \theta \sigma \kappa_s], \]
\[ \zeta \equiv \alpha \psi + \mu \eta + \sigma \theta. \]

(Recall that we normalize \( \kappa_a \) to zero.) Similarly, let \( \ell \) denote the average labor market distortion:

\[ \ell = \frac{1}{1 - \zeta} [\eta (1 - \mu) \ell_m + \theta (1 - \sigma) \ell_s]. \]

Using these definitions, we show in Appendix A that in equilibrium equations (2)\(^5\) Any effects that government spending might have on utility or production will be captured by correlations between government spending and the other wedges. Chari et al. (2007) provide several useful examples.
and (7) can be written as

\[ Y = A^{1-\zeta} K^{\zeta} L^{1-\zeta}, \quad (8) \]

\[ (1 - \zeta)(1 + \ell)(1 - \tau_t) \frac{Y}{C} = \chi \left( \frac{L}{N} \right)^{1+\gamma}. \quad (9) \]

where

\[
A \equiv \left[ A_f A_a A_m A_s \Omega \Delta \right]^{1/(1-\zeta)}, \\
\Omega \equiv \frac{(1 + \kappa_m)^\eta (1 + \kappa_s)^\eta}{(1 + \kappa)^\zeta}, \\
\Upsilon \equiv \frac{(1 + \ell_m)^\gamma (1 + \ell_s)^\gamma}{(1 + \ell)^{1-\zeta}}, \\
\Delta \equiv \left( \psi \left( \frac{\alpha}{\zeta} \left( \frac{1 - \alpha}{1 - \zeta} \right)^{1-\alpha} \right) \right)^\psi \left( \eta \left( \frac{\mu}{\zeta} \left( \frac{1 - \mu}{1 - \zeta} \right)^{1-\mu} \right) \right) \left( \theta \left( \frac{\sigma}{\zeta} \left( \frac{1 - \sigma}{1 - \zeta} \right)^{1-\sigma} \right)^\theta. \right)
\]

As noted above, \( K = K_a + K_m + K_s \) and \( L = L_a + L_m + L_s \) denote aggregate capital and labor, respectively. \( A \) denotes aggregate productivity, expressed here in labor-enhancing form. \( \Omega \) measures the efficiency lost due to sectoral misallocations of capital, while \( \Upsilon \) measures the efficiency lost due to sectoral misallocations of labor. Note that when there are no sectoral misallocations, \( \kappa = \kappa_m = \kappa_s = 0, \ell = \ell_m = \ell_s = 0, \) and \( \Omega = \Upsilon = 1. \)

Similarly, the equilibrium Euler equation becomes:

\[
\frac{N_t}{C_t} = \beta E_t \left[ \frac{N_{t+1}}{C_{t+1}} \left[ 1 + \zeta_{t+1} (1 + \kappa_{t+1}) \frac{Y_{t+1}}{K_{t+1}} - \delta_{t+1} \right] \right] \frac{1}{1 + \tau_{kt}}. \quad (11)
\]

15
Finally, we have the capital accumulation equation:

$$K_{t+1} = (1 - \delta_t)K_t + Y_t - C_t - G_t.$$  \hspace{1cm} (12)

### 2.2.5 A Stationary Transformation

The next step is to express the model in intensive quantities suitable for numerical analysis. We assume, consistent with the data, that productivity follows a stationary process around the trend $A^*$. Let lower case variables denote upper case variables divided by population and this productivity trend, with $c_t \equiv C_t / (A_t^* N_t)$, and so on. Labor hours are normalized by population, so that $l_t = L_t / N_t$. With these definitions, we can rewrite the Euler and capital accumulation equations as

$$\frac{1}{c_t} = \beta \frac{N_{t+1}}{N_t} E_t \left( \frac{1}{c_{t+1}} (G_{t+1}^*)^{-1} \left[ 1 + \zeta_{t+1} (1 + k_{t+1}) \frac{y_{t+1}}{k_{t+1}} - \delta_{t+1} \right] \right) \frac{1}{1 + \tau_{kt}},$$  \hspace{1cm} (13)

$$G_{t+1}^* k_{t+1} = (1 - \delta_t)k_t + y_t - k_t - g_t,$$  \hspace{1cm} (14)

$$y_t = \left( k_t^\zeta a_t^{1 - \zeta_t} \right)^{\phi_t} c_t^{1 - \phi_t} \Gamma_t^{\phi_t - 1}.$$  \hspace{1cm} (15)

where

$$G_{t+1}^* \equiv \frac{N_{t+1} A_{t+1}^*}{N_t A_t^*},$$

$$\Gamma_t \equiv \frac{1}{\chi} (1 - \zeta_t)(1 + \ell_t)(1 - \tau_{lt}),$$

$$a_t \equiv A_t / A_t^*, \quad \phi_t \equiv \frac{1 + \gamma}{\gamma + \zeta_t} = 1 + \frac{1 - \zeta_t}{\gamma + \zeta_t}. $$

16
(See Appendix A) It bears emphasizing that the trend term $G^*$, although deterministic, can vary over time.

### 2.3 Finding the Time-varying Parameters and the Wedges

The key to the accounting procedures developed by Chari et al. (2007), Mulligan (2005) and others is that the economy’s distortions, or “wedges” can be calculated by rearranging the equations of the model and applying them to the data. In our variant of the accounting methodology, we proceed in two steps. First we find the time-varying parameters. Then we use the parameter values to calculate the wedges.

#### 2.3.1 Time-Varying Parameters

To derive the sectoral shares, rewrite equations (3a)-(3c) as

\[
\begin{align*}
\psi_t &= \frac{p_{at}Y_{at}}{p_tY_t}, & (16a) \\
\eta_t &= \frac{p_{mt}Y_{mt}}{p_tY_t}, & (16b) \\
\theta_t &= 1 - \eta_t - \psi_t = \frac{p_{st}Y_{st}}{p_tY_t}. & (16c)
\end{align*}
\]

In making this derivation, we are assuming that there are no distortions in the choice of intermediate goods, so that changes in sectoral shares are due only to changes in the aggregate production function. Lahiri and Yi (2006) take the opposite position, assuming that $\eta$, $\theta$, and $\psi$ are constant, and that any variation in sectoral shares reflects distortions faced by final goods producers. Although the two approaches are observationally equivalent in terms of equations (16a) - (16c), our approach is more
consistent with the prevailing view that India has experienced major sectoral shifts.

Similarly, we can estimate a series of depreciation rates from equation (12):

$$
\delta_t = \frac{1}{K_t} [I_t + K_t - K_{t+1}].
$$

### 2.3.2 Fixed Parameters

Calculating the wedges also requires several other parameters, which we assume are fixed throughout our time period.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>agriculture capital share</td>
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<tr>
<td>$\mu$</td>
<td>manufacturing capital share</td>
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<tr>
<td>$\sigma$</td>
<td>services capital share</td>
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<tr>
<td>$\beta$</td>
<td>time discount factor</td>
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</tr>
<tr>
<td>$\gamma$</td>
<td>$1/IES_{\text{lab}}$</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1.1. Calibrated Parameters

The capital shares are taken from Bosworth et al. (2007). The value for $\beta$, the rate of time preference, is standard. The value for $\gamma$ implies an intertemporal supply elasticity for labor of 1. Although this value is lower than the value taken in many macro studies, it is consistent with more recent micro-level studies: Hall (2008) concludes that recent estimates imply an elasticity of 0.9.

---

6Bosworth et al.’s (2007) factor shares for agriculture include a component for land (0.25), which we divided evenly between capital and labor.
2.3.3 Wedges

The sectoral productivity levels can be computed from equations (1a)-(1b), as

\[
A_{at} = \frac{Y_{at}}{K_{at}^{\alpha} L_{at}^{1-\alpha}},
\]
\[
A_{mt} = \frac{Y_{mt}}{K_{mt}^{\mu} L_{mt}^{1-\mu}},
\]
\[
A_{st} = \frac{Y_{st}}{K_{st}^{\sigma} L_{st}^{1-\sigma}},
\]

while the aggregate productivity shifter \( A_f \) can be computed from equation (2), as

\[
A_f = \frac{Y_f}{Y_a^{\alpha} Y_{mt}^{\gamma} Y_{st}^{\delta}}.
\]

In addition, when \( p_{at} = p_{mt} = p_{st} = p_t \), it follows from equations (16a)-(16c) that

\[
Y_t = A_{ft} (\psi_t Y_t)^{\psi_t} (\eta_t Y_t)^{\eta_t} (\theta_t Y_t)^{\theta_t} \Rightarrow A_{ft} = \left[ \psi_t^{\psi_t} \eta_t^{\eta_t} \theta_t^{\theta_t} \right]^{-1}. \tag{18}
\]

Because India’s price data show no pronounced trends in relative prices, we assume that \( p_{mt}, p_{st} \) and \( p_t \) are constant, and employ this simplifying approximation, both here and in calculating the sectoral shares.

Equations (5a)-(5c) show that the capital distortions \( \kappa_m \) and \( \kappa_s \) solve:

\[
1 + \kappa_{mt} = \frac{\psi_t \alpha K_{mt}}{\eta_t \mu K_{st}} = \frac{MPK_{at}}{MPK_{mt}},
\]
\[
1 + \kappa_{st} = \frac{\psi_t \alpha K_{st}}{\theta_t \sigma K_{at}} = \frac{MPK_{at}}{MPK_{st}}.
\]

Finding the aggregate distortion \( \kappa_t \) is straightforward. The labor distortions are found
in a similar manner:\footnote{\cite{LahiriYi2006} calculate the same labor distortions under the names $\omega^{l,am}$ and $\omega^{l,as}$. They also calculate capital distortions, under the names $\omega^{k,am}$ and $\omega^{k,as}$.}

\[
1 + \ell_{mt} = \frac{\psi_t(1 - \alpha)}{\eta_t(1 - \mu)} \frac{L_{mt}}{MPL_{mt}}, \\
1 + \ell_{st} = \frac{\psi_t(1 - \alpha)}{\theta_t(1 - \sigma)} \frac{L_{st}}{MPL_{st}}.
\]

It bears repeating that if labor is measured as raw employment, $\ell_{mt}$ and $\ell_{st}$ could reflect differences in skill—which affect the marginal product of raw employment—as well as misallocation. Let $q_{at}$, $q_{mt}$ and $q_{st}$ denote skill measures. We can then decompose $\ell_{mt}$ and $\ell_{st}$ into

\[
1 + \ell_{mt} = (1 + \ell_{1mt})(1 + \ell_{2mt}), \\
1 + \ell_{2mt} = \frac{q_{at}}{q_{mt}}; \quad 1 + \ell_{1mt} = \frac{1 + \ell_{mt}}{1 + \ell_{2mt}}, \\
1 + \ell_{st} = (1 + \ell_{1st})(1 + \ell_{2st}), \\
1 + \ell_{2st} = \frac{q_{at}}{q_{st}}; \quad 1 + \ell_{1st} = \frac{1 + \ell_{st}}{1 + \ell_{2st}}.
\]

If $q_{at}$, $q_{mt}$ and $q_{st}$ are accurate, $\ell_{1mt}$ and $\ell_{1st}$ provide “true” measures of misallocation.

The parameter $\chi$ and the series $\{\tau_{lt}\}$ solve the following version of equation (9):

\[
\chi t^{1+\gamma} = (1 - \zeta_t)(1 + \ell_t)(1 - \tau_{lt}) \frac{Y_t}{G_t}.
\]

Because this approach provides $T$ equations to identify $T + 1$ parameters, additional information must be imposed. We utilize Poirson (2006, Table 2), who calculates...
India’s effective tax rate on labor income, \( \tau_{lt} \), to be about 16% over the period 1993-2000. Taking averages over the same period, we find that \( \chi = 0.90825 \), and with \( \chi \) in hand, we can back out \( \{\tau_{lt}\} \).

Government spending can be inferred as

\[
G_t = Y_t + (1 - \delta_t) K_t - C_t - K_{t+1}.
\]

Because we model the Indian economy as closed, these “government spending” shocks will reflect any changes in net exports.

The capital tax \( \tau_{kt} \) can be calculated by rearranging the Euler equation. Because of the expectation on the right-hand side of the Euler equation, finding \( \tau_{kt} \) is tricky (Chakraborty, 2006; Chari et al., 2006, 2007; Bäurle and Burren, 2007.) We use the approximation adopted by Kobayashi and Inaba (2006), and replace expectations with realized values. We therefore estimate the approximate tax \( \tilde{\tau}_{k,t+1} \):

\[
\tilde{\tau}_{k,t+1} = \beta \frac{N_{t+1}}{N_t} \left( \frac{C_t}{C_t+1} \left[ 1 + \zeta_{t+1}(1 + \kappa_{t+1}) \frac{Y_{t+1}}{K_{t+1}} - \delta_{t+1} \right] \right) - 1, \quad \tau_{kt} = E_t(\tilde{\tau}_{k,t+1}).
\]

Because \( \{\tilde{\tau}_{k,t+1}\} \) differs from \( \{\tau_{kt}\} \) only by a sequence of uncorrelated forecast errors, it should provide a reasonable basis for estimating the trend \( \{\tau_{kt}^*\} \). The measurement of the deviation \( \tau_{kt} - \tau_{kt}^* \) is more involved; we discuss this point in section 2.7.1 below.
2.4 Solving the Model

Once we have calculated the wedges, we can solve the model numerically to assess their importance. This is the “accounting” part of the BCA methodology.

The full model has 10 stochastic state variables, as well as capital, and four time-varying parameters. Moreover, the model cannot be expressed as the solution to a social planner’s problem. We therefore adopt the common practice of separating the model into “trend” and “cycle” components, and solving the model in steps. The first step is to solve the perfect foresight “trend” model. In particular, we estimate the trends \( \{ G^*_t, \Gamma^*_t, \kappa^*_t, \tau^*_{kt}, g^*_t, \zeta^*_t, \delta^*_t \} \), set \( a^*_t = 1 \), and solve a deterministic version of the model using these series. The second step is to use the trend series \( \{ k^*_t, c^*_t \} \) generated in the first step, along with the exogenous trends, as the base points for a time-varying linearization.
2.4.1 Finding the Trend

We find the trend series by using equations (13) - (15) to produce the sequence \( \{k_t^*, c_t^*\}_{t=1960}^{2094} \). Because \( \{G_t^*, \Gamma_t^*, \kappa_t^*, \tau_{kt}^*, g_t^*, \zeta_t^*, \delta_t^*\} \) are treated as known, there are no expectations involved, and the recursion is simple.\(^8\) This leaves the problem of finding the initial pair \((k_{60}^*, c_{60}^*)\). To find \(c_{60}\), we assume that for \(t \geq 2035\), \(\{G_t^*, \Gamma_t^*, \kappa_t^*, \tau_{kt}^*, g_t^*, \zeta_t^*, \delta_t^*\} \) are constant. (For the period 2006-2035, we extrapolate from the data trends shown below.) Because our model has the usual stability properties, it follows that by 2094 the deterministic economy will have converged to a steady state (in intensive quantities), and that for any initial capital stock \(k_{60}\) there is a unique initial consumption level \(c_{60}\) that takes the economy to this steady state. The stable value \(c_{60}^* = c^*(k_{60})\) is straightforward to find. To find \(k_{60}^*\), we find the value of \(k_{60}\) that minimizes the total squared log deviations between the trend series \(\{k_t^*, c_t^*, l_t^*\}\) and their data counterparts.

2.4.2 Finding Deviations from Trend

We model the effects of “non-trend” movements in \(\{G_t, \Gamma_t, \kappa_t, \tau_{kt}, g_t, \zeta_t, \delta_t\}\) on the model’s endogenous variables by linearizing the model around the trend values described immediately above. This is an extension of the approach used by King et al. (1988, 2002) and many others.\(^9\) The only substantive difference is that the matrices

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\(^8\)The only wrinkle is that with endogenous labor supply, the choice of \(c_{t+1}\) in equation (13) also affects \(y_{t+1}\), so that even when \(c_t, k_t\), and \(k_{t+1}\) are known, there is no closed form solution for \(c_{t+1}\). However, it follows from equation (15) that \(y_{t+1}\) is decreasing in \(c_{t+1}\), so that given \(k_{t+1}\), the right-hand-side of equation (13) is monotonically decreasing in \(c_{t+1}\), and a numerical search is straightforward.

that describe our solution vary over time; the standard approach, which linearizes around a steady state, yields time-invariant matrices. Given that the parameters of the Indian economy appear to have changed significantly over the past 45 years, we view this time variation as a valuable feature.\footnote{Allowing time variation introduces a small amount of imprecision into our solution; Appendix A provides a detailed discussion. Ignoring time variation, however, would arguably introduce more inaccuracy. For example, the parameter } \theta \text{, the share of services, rises 27 percentage points over the sample period. In contrast, the magnitude of the solution errors appears to be less than 1 percent of the consumption deviations.} \footnote{Allowing time variation introduces a small amount of imprecision into our solution; Appendix A provides a detailed discussion. Ignoring time variation, however, would arguably introduce more inaccuracy. For example, the parameter \theta, the share of services, rises 27 percentage points over the sample period. In contrast, the magnitude of the solution errors appears to be less than 1 percent of the consumption deviations.}

\section*{2.5 Data}

The data for the Indian economy that we use are annual observations from 1960 through 2005 (or 2006). The data include: real output by expenditure; real output and capital by sector; employment and worker quality by sector; and population.

Almost all these data were compiled and constructed by Bosworth et al. (2007), who provide a detailed description. With the exception of employment, their data are largely standard. Bosworth et al. derive sectoral employment by combining population data from the census and total workforce data from quinquennial household surveys. The same surveys also allow Bosworth et al. to calculate the average years of schooling for workers in each sector. Assuming that each year of schooling increases earnings by 7 percent, Bosworth et al. convert the schooling data into indices of worker quality.

Two data series come from other sources. Our measure of consumption is the one in the national accounts, rescaled to be consistent with Bosworth et al.’s measures of...
total output and investment. We define population, \( N \), to be the number of people between ages 15 and 70. Our historical population measures are found by combining data from the United Nations (Population Division, 2008) and national accounts data. To solve our model, we also need population projections, for which we use the United Nations’ (Population Division, 2008) “medium variant” forecast.
2.6 Trend Results

2.6.1 Trends in wedges

To find the trends for the time-varying parameters and wedges, we utilize a flexible curve-fitting approach. With relatively little theoretical guidance, the specifications were chosen to fit the data well and make reasonable projections.\textsuperscript{11}

Figure 2.1. Sectoral Shares: Data and Trends

Figure 2.1 shows the estimated sectoral shares ($\psi_t$, $\eta_t$ and $\theta_t$) and their trends, which are estimated as logistic functions of time, with a trend break in 1990. The share of agricultural output declines through the whole sample period, falling from

\textsuperscript{11}In general, we assume that the trends follow our estimated trend equations until 2035, and then stay stable. The two exceptions are fiscal policies and depreciation, for which we did not feel comfortable making extended projections. We simply assume these variables stay at their 2005 (or 2006) trend values for the foreseeable future. Appendix A shows the projected trends. Our results do not appear sensitive to these assumptions.
55 to 18 percent. Offsetting this is a rapid increase in the service sector share, from 26 to 53 percent. Manufacturing, the smallest of the three sectors at the beginning of 1960, also surpassed agriculture, in the mid-nineties. The structural shifts appear to have accelerated since 1990, suggesting that the “pro-market” reforms beginning at that time have facilitated the economy’s transformation.

The three sectoral productivity wedges ($A_{at}, A_{mt}$ and $A_{st}$) are estimated as logarithmic functions of a time trend, with a trend break around 1982,\(^\text{12}\) most observers

\[^{12}\text{We are assuming that the productivity trends shifted slowly over the course of 6 years, rather than in a 1-period break. In all other respects, however, we treat the trend break as known in advance; our ability to divide the data into trend and deviations relies on this assumption. In contrast, Aguiar and Gopinath (2007) argue that trend breaks are the primary source of business cycles in emerging economies.}\]
conclude that the Indian economy experienced a structural shift around that time (Bai and Perron, 1998, 2003; Williamson and Zagha, 2002; Virmani, 2004; Rodrik and Subramanian, 2004). Figure 2.2 shows the productivity wedges and their trends. The trends all slope more steeply after 1980, with the most pronounced increase in the service sector.\footnote{This change in trend is consistent with the argument that reforms begun in the early 1980s were at least in part responsible for the higher growth rates of the past 25 years.}

Figure 2.3 shows the capital market distortions, ($\kappa_{mt}$ and $\kappa_{st}$), the labor market distortions ($\ell_{mt}$ and $\ell_{st}$), and their respective trends. Both capital distortions are positive, implying that India’s capital-related policies favor the service and especially the manufacturing sectors over agriculture. While the capital distortion in the manufacturing sector, $\kappa_{mt}$, has grown over the sample period, the service sector distortion, $\kappa_{st}$, has shrunk. Both labor market distortions are negative, implying that not enough labor is supplied to the manufacturing and service sectors, and the shortage appears to be getting worse over time. Lahiri and Yi (2006, 2008) find similar trends in their

\footnote{Bosworth et al. (2007, p. 39) find the amount of growth in India’s service sector productivity to be “quite puzzling”, and perhaps exaggerated by measurement error.}
Because $\ell_{mt}$ and $\ell_{st}$ reflect ratios of the marginal product of raw labor hours, it is possible that these negative values arise because non-agricultural labor is more skilled. To account for this possibility, we use the education measure constructed by Bosworth, et al. (2007) to construct the quality-adjusted distortions described in Section 2.3, $\ell_{1mt}$ and $\ell_{1st}$. These measures are somewhat less extreme than the measures shown in Figure 2.3, but they are nonetheless negative, large and growing larger. As Lahiri and Yi (2006, p. 17) point out, large negative values of $\ell_m$ and $\ell_s$ "reflect a well known characteristic of developing countries, the concentration of the
workforce in agriculture, a sector with low productivity.” They are also consistent with the belief that India’s markets face many barriers, both regulatory (Besley and Burgess, 2004) and social (Verma, 2008, section 3), to labor mobility. The growth in these distortions is perhaps more surprising, but is consistent with Bosworth et al. (2007, p. 4), who “find evidence of shortages among the group of highly-educated workers (university graduates) who have done so well in recent years.”

Figures 2.4 and 2.5 show the fiscal policy wedges and the estimated depreciation rates. The capital tax rate \((\tau_{kt})\) has shrunk over the sample period, while intensive government spending \((g_{2t})\) has risen. Neither the labor tax rate \((\tau_{lt})\) nor the depreciation rate \((\delta_{t})\) show any pronounced trends.
2.6.2 Benchmark model and counterfactuals

The benchmark model uses the wedge trends estimated in the preceding section to generate time paths for the endogenous variables; transitional dynamics aside, any trends in the endogenous variables are attributable to trends in the wedges. Figure 2.6 compares the model-generated trends in logged per-capita capital, consumption and output to their data counterparts. Figure 2.7 makes the same comparison for employment rate. In general the fits are good.
To determine which wedges had the biggest impacts on the Indian economy’s trend path, we do several counterfactual exercises. For instance, we allow no growth in the trend wedges, both individually and collectively, and measure how output and employment change from their benchmark trends. Table 2.2 summarizes fifteen such counterfactual experiments. Figures 2.8 and 2.9 show per capita output and employment rates for the data, the baseline model, and all the counterfactual experiments.

The increase in total factor productivity (TFP) in the service sector is arguably the
single most important trend. When TFP in this sector is locked at its 1960 value for rest of the period, output in 2005 falls from 21.35 (thousand rupees) in the benchmark case to 10.88. The annual growth rate declines from 2.31% to 0.70%. Given that our flow utility function is separable and logarithmic in consumption, persistent changes in TFP have relatively little effect on employment: the employment rate in 2005 declines from 0.61 to 0.58. Collectively, when there is no growth in any of the TFP trends, output in 2005 falls even further, to 8.79, and output growth declines to 0.23% per year.

The aggregate effect of improved service sector productivity would have been much smaller, however, had the Indian economy not been willing to accept more services,
either as final goods, or as tradable exports. If the sectoral shares in the aggregate production function had not changed, output in 2005 would have been 16.45, 20% less than its actual value. Our results suggest that without sectoral shifts, India’s annual output growth rate would have been about 0.3 percentage points lower over the period 1960-1980, and about 0.8 percentage points lower over the period 1980-2005. Adapting the standard growth accounting approach, Bosworth et al. (2007) estimate that “reallocating effects” increase annual output growth by 0.4 and 1.0 percentage points over the periods 1960-1980 and 1980-2004, respectively.

The effects of holding the quality-adjusted labor market distortions, $\ell_{1m}$ and $\ell_{1s}$, at their 1960 values are also significant. If the distortions are held fixed, output in 2005 rises from 21.35 to 29.37, while the employment rate rises from 0.61 to 0.72. If the labor market distortion in the service sector alone could be restrained at its 1960 value, then the annual growth rate would have increased to 2.68%, and employment in 2005 would have increased to 0.68. Conversely, if the sectoral shares had remained at their 1960 values, the labor shortage in the manufacturing and service sectors would have been much less important to the overall economy. With the service share held fixed, employment in 2005 rises from 0.61 in the benchmark model to 0.77.
<table>
<thead>
<tr>
<th></th>
<th>Per Capita Output (1000s of 1993-94 Rs)</th>
<th>Employment Rate</th>
<th>CAGR(^\dagger)</th>
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<tr>
<td>Data</td>
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<td>9.65</td>
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<tr>
<td>Benchmark Model</td>
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<td>7.88</td>
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\(^\dagger\) Annual growth rates
\(^\dagger\) Labor distortions adjusted for education level

Table 2.2. Per Capita Output: Data and Model-Generated Trends
Although we have adjusted our labor distortion measures for education levels, using the index constructed by Bosworth et al. (2007), it is possible that we have not adequately controlled for skill or effort. Our findings are consistent, however, with Bosworth and Collins’ (2008, p. 63) claim that “India faces serious deficiencies in the education of the bulk of its youth population,” and the widespread belief that India’s labor markets operate inefficiently (Verma, 2008). The long-run effects of the labor distortions are potentially quite large: if the distortions are held at their 1960 values,
rather than our projections, output in 2035 will be nearly two and a half times as large. Such a long-range prediction is of course speculative, but even over the sample period the worsening of the labor distortions has reduced output by over 27%.

The effects of the capital market distortions are more modest. Recall that positive values of $\kappa_{mt}$ and $\kappa_{st}$ imply that capital in the manufacturing and service sectors is being subsidized. As a result, setting $\kappa_{mt}$ at its 1960 value, which is the lowest observed, reduces capital accumulation and output growth. Conversely, setting $\kappa_{st}$ at its 1960 value, which is among the highest observed, stimulates growth. When both distortions are set to their 1960 values, their effects offset and output and employment both stay near their benchmark values.
The aggregate effect of direct fiscal policies—labor taxes, capital taxes and government expenditures—is mixed. Capital taxes have fallen over the sample period, so that keeping them at their 1960 value lowers output in 2005. Government expenditures have grown over the sample period. Because the wealth effect of government expenditures is to increase labor supply, if $g_{2t}$ is set to its 1960 value, the year-2005 employment rate falls from 0.61 to 0.56, and output falls as well. Labor taxes, on the
other hand, have risen over the sample period, so that setting these taxes at their 1960 values would raise both employment and output. Collectively, when the three fiscal wedges are held at their respective 1960 values, output in 2005 falls from 21.35 to 15.73, a 26% decrease, while the employment rate falls from 0.61 to 0.54.

Put together, the “direct” effect of India’s fiscal policy changes is higher output. Taken as a whole, however, the counterfactual trend experiments indicate that growth in service sector productivity is most important source of output growth in the Indian economy over the last four decades. Bosworth et al. (2007) and Bosworth and Collins (2008), using standard growth accounting, reach a similar conclusion. Like Chakraborty (2006), we conclude that the main contribution of India’s policy reforms has almost surely been through indirect channels, as changes in the regulatory environment manifested themselves as changes in TFP or sectoral composition.

2.7 Business Cycle Results

2.7.1 VAR estimation of wedge deviations

We model the trend deviations of the wedges and the time-varying parameters as a first-order vector autoregression:

\[
\begin{align*}
\mathbf{w}_{t+1} & = \mathbf{Pw}_t + \mathbf{\epsilon}_{t+1}, \\
\mathbf{\epsilon}_{t+1} & = \mathbf{Q\xi}_{t+1}, \\
\mathbf{w}_t & = \begin{bmatrix} \hat{a}_{at} \hat{a}_{mt} \hat{a}_{st} \hat{\kappa}_{mt} \hat{\kappa}_{st} \hat{\ell}_{mt} \hat{\ell}_{st} \hat{\tau}_{kt} \hat{\tau}_{lt} \hat{\gamma}_t \hat{\delta}_t \hat{\psi}_t \hat{\theta}_t \end{bmatrix}.
\end{align*}
\]
where the elements of $\xi_t$ are unit-variance and uncorrelated, and $Q$ is the lower triangular Cholesky decomposition of the covariance matrix of $\epsilon_{t+1}$. The coefficient matrix $P$ is restricted to be diagonal, but $Q$ is unrestricted, so that the wedges are not independent. We found that this parsimonious specification did a good job of capturing the correlations observed in the data. Table 2.3 presents the coefficient matrix $P$. In general, the wedge deviations are weakly correlated across time; service sector TFP has the largest autocorrelation, at 0.78. Table 2.4 presents the Cholesky decomposition $Q$.

Recall from Section 2.3.3 that the measurement of the capital tax $\tau_{kt}$ is complicated by the expectation in the Euler equation. We work instead with the realized tax $\bar{\tau}_{k,t+1}$, where $\tau_{kt} = E_t (\bar{\tau}_{k,t+1})$, which allows us to calculate the trend series $\tau^*_{kt}$. By assuming that $\bar{\tau}_{k,t+1}$ follows an exogenous univariate AR(1) process around this trend, we can estimate $\bar{\tau}_{kt}$. In particular, if $\bar{\tau}_{k,t+1} - \tau^*_{kt}$ follows a univariate AR(1) process, then

$$\bar{\tau}_{kt} = \tau_{kt} - \tau^*_{kt} = E_t (\bar{\tau}_{k,t+1} - \tau^*_{kt}) = \rho_{\tau_k} (\bar{\tau}_{kt} - \tau^*_{k,t-1}),$$

where $\rho_{\tau_k}$ is the autoregressive coefficient. Given that $\rho_{\tau_k} = -0.03$ (Table 2.3), the end result is that capital taxes play no meaningful role in our cycle analyses.
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Table 2.3. Vector AR(1) Coefficients
Combining the wedge deviations estimated in the preceding section with the log-linearized model described in section 2.4.2, we simulate the fluctuations of the model’s endogenous variables, and compare them to the data.
Figure 2.10 compares the model-generated output series with its data counterpart.

The first row of Table 2.5 shows the standard deviation of the output fluctuations observed in the data. To allow for the possibility that India’s reforms have changed the nature of its business cycles, we consider results both for the entire sample, 1960-2005, and for the subperiods 1960-1980 and 1981-2005. The first row of Table 2.5 shows that the standard deviation drops about 31%, from 2.93% to 2.01%, between the two subsamples. In contrast to Chari et al. (2007), who capture capital distortions in a “investment wedge” that makes the model fit the data, our model is not guaranteed to reproduce the data. Nonetheless, the fit is good, especially during the first half of the sample period. The second (“All wedges”) row of Table 2.5 shows that during
the 1960-1980 subsample, the fit between the observed output series and its model-generated counterpart is almost perfect: the correlation between the two series is about 98%. Although the correlation during the second subsample drops to 80%, the overall fit of the model for the entire sample period is reasonably good at about 87%. The model is also able to generate as much volatility as observed in the data; in fact, the model generates too much volatility.

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<tr>
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<th>Standard deviation (percent)</th>
<th>Correlation with data (percent)</th>
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<td>Data</td>
<td>2.93 2.01 2.52</td>
<td>97.6 79.7 87.1</td>
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<td>Model: All Wedges</td>
<td>3.63 2.17 2.86</td>
<td>94.5 48.1 71.1</td>
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<tr>
<td>Model: TFP Wedges Only</td>
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<td>All sectors</td>
<td>3.67 3.21 3.37</td>
<td>43.8 28.2 22.4</td>
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<td>Service sector</td>
<td>0.61 1.93 1.50</td>
<td>44.9 28.9 26.3</td>
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<td>Manufacturing sector</td>
<td>0.82 1.42 1.20</td>
<td>84.1 32.4 67.2</td>
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<td>3.37 1.80 2.59</td>
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<tr>
<td>All sectors</td>
<td>1.42 1.15 1.26</td>
<td>83.0 12.8 50.2</td>
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<td>89.7 12.3 45.7</td>
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<td>Manufacturing sector</td>
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<td>0.51 0.30 0.40</td>
<td>79.3 20.6 53.1</td>
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<tr>
<td>Agricultural sector</td>
<td>0.94 0.76 0.83</td>
<td>-59.9 -3.3 -35.9</td>
</tr>
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Table 2.5. Output Deviations from Trend: Data and Model
Next we conduct a number of counterfactual experiments to determine which wedges can best account for India’s output fluctuations. Following standard BCA practice, we set various wedge series to zero, individually or jointly, and re-solve the model. Table 2.5 summarizes eighteen such counterfactual exercises; row headings show which wedges have not been shut down.\(^\text{14}\)

The three sector-specific TFP shocks are the most significant wedges. Figure 2.11 compares the data to the output series generated by the model with all three TFP wedges in action.

![Figure 2.11. Output Fluctuations: Data and Model with All TFP Wedges](image)

Table 2.5 shows that the TFP-only output series correlate with the data at 95%\(^\text{14}\) It bears noting that because the wedge series are not orthogonal, these experiments do not produce a true variance decomposition.
and 48% in the first and second sub-periods, respectively. Table 2.5 also shows that the TFP-only model generates by far the most volatility. Figures 2.12 and 2.13 illustrate the effects of the sector-specific TFP shocks. During the first subsample, TFP shocks in the agricultural sector generated 93% as much volatility as all the TFP wedges combined. Moreover, the correlation between agricultural-TFP-only output and observed output was 84%. The prominent role of agricultural TFP shocks may in part reflect the Green Revolution, consisting mainly of the spread of high-yield rice and wheat varieties, which started in 1967/68. In the second subsample, on the other hand, agricultural TFP shocks generate much less volatility; service sector TFP shocks appear to be more important. Much of the shift is simply due to the shift from agriculture to services in the overall economy. With our time-varying linearization, changes in sectoral shares translate immediately into changed effects.
Labor market distortions appear significant during both periods of our analysis (Figure 2.14). When combined, labor market distortions can account for 48% of the output volatility observed in the first subsample and 57% of the volatility observed in the second. Like their associated trends, many fluctuations in the labor market distortions probably reflect changes in skill or effort that affect the marginal product of labor. A striking result is that while the labor market distortions have a strong positive correlation with output in the first subsample (83%), they have virtually no correlation in the second. It is possible that this difference reflects changes in India’s labor market institutions.
Figure 2.13. Output Fluctuations: Data and Model with Manufacturing and Service TFP Wedges
Capital market distortions (Figure 2.15) and our measure of aggregate capital taxes play a very small role in accounting for India’s business cycles. This does not necessarily mean that capital market frictions are unimportant in explaining India’s business cycles. As Chakraborty (2006) points out, because we do not set the investment wedge to make the model fit the data, any residual movements in the data not captured by our model can be interpreted as reflecting investment wedges of the type envisioned by Chari et al. (2007). These residual movements—the gaps between the data and complete-model-generated output shown in Figure 2.10 and Table 2.5—imply that the effects of such investment wedges, although small, are not
Labor taxes play a major role. In both subsamples, the model with fiscal policy shocks is the second most volatile, and in both subsamples labor taxes are the dominant fiscal policy shock. As Figure 2.16 and Table 2.5 show, labor taxes often move in the opposite direction of output, especially during the first subsample, where the correlation between labor taxes-only output and the data is -60.1%. Given that an increase in labor taxes depresses labor supply, this is not surprising. A second, subtler reason for a negative correlation is that the labor tax wedge embodies aggre-
gate labor market frictions. (See the extensive discussion in Mulligan, 2005.) India has stringent labor laws (Besley and Burgess, 2004), as well as social barriers to job mobility (Verma, 2008). One implication of such labor market frictions is that when a shock to TFP or another wedge occurs, the response of the labor market is smaller than predicted by a frictionless model. To fit the data, a shock that moves output will have to be accompanied by a “labor tax” shock of the opposite direction that dampens the labor response; the end result is that the taxes are negatively correlated with output (Jones, 2002).

Fluctuations in government expenditures, depreciation rates, and sectoral shares all have very modest effects. One interesting feature is that fluctuations in the service sector share are positively correlated with output, while fluctuations in the agricul-

Figure 2.16: Output Fluctuations: Data and Model with Aggregate Labor Tax Wedge

51
tural share are negatively correlated. This reinforces our finding from the trend model that India’s transition from agriculture to services was an important contributor to its recent growth.

In short, our BCA exercises suggest that just as changes in sector-specific TFP are the principal driver of India’s trend growth, they are the principal driver of its business cycles. In the period 1960-1980, TFP shocks in the agricultural sector were the dominant source of fluctuations. As the economy transitioned away from agriculture, output volatility fell and TFP shocks to manufacturing and services became more important. Labor market distortions and aggregate labor taxes are both significant as well, suggesting that labor market frictions are an important component of India’s business cycle dynamics.

2.8 Conclusion

This paper develops a quantitative methodology specifically designed for analyzing the economic dynamics of developing economies. Our approach accounts for time-varying parameters, transitional dynamics and non-linear trends. We apply this methodology to the Indian economy over the period 1960-2005 to study both its long-run trends and its fluctuations around these trends.

Our findings indicate that increased total factor productivity in the service sector, facilitated by a structural shift toward services, has been the principal driver of India’s growth. We also find that the apparent misallocation of labor has hindered output growth for several decades, and is growing worse. Although it is possible that these
distortions reflect unmeasured differences in skill and/or effort, they suggest large inefficiencies. If the distortions continue their current trend, future growth will be significantly constrained.

Our analysis also suggests that short-run fluctuations in the Indian economy have been caused mainly by fluctuations in sector-specific productivity. During the period 1960-1980, fluctuations in agricultural productivity dominated India’s business cycles. Over time, however, India has shifted from an agricultural economy to a service economy. Since 1980, total output volatility has been lower, and manufacturing and service sector productivity shocks have been the leading source of output fluctuations. Labor market distortions, both between sectors and collectively, have also had a significant effect on output fluctuations.

Despite its reliance on a formal model, our approach is an accounting methodology that does not provide structural interpretations. Our results instead identify areas where structural analysis should be most productive. Three topics appear especially promising: (i) Is the rapid growth of service sector productivity due to the removal of technology barriers, a la Parente and Prescott (2000), or improved input allocation across existing technologies? (ii) What are the mechanisms that allow rapid productivity growth in the service sector to translate into a higher share of output: substitution away from goods or trade?\textsuperscript{15} and (iii) Do the large sectoral differences in labor productivity reflect frictions or differences in skill? Investigations into any of these questions should be quite useful.

\textsuperscript{15}Verma (2008) considers this issue, and concludes (p. 30) “an export-led growth hypothesis of service sector growth is difficult to support.”
3 Source of Service Sector TFP Growth in India- Evidence from Micro Data

3.1 Introduction

In recent years, economic growth in India has been driven by the service sector. Rapid growth in total factor productivity or TFP in the service sector, coupled with an increasing share of this sector in aggregate output, have accelerated the overall pace of growth of the Indian economy (Table 3.1).

During 1980-2008, aggregate Gross Domestic Product or GDP registered an average annual growth rate of 6 percent, while the growth rate of output of the service sector was recorded at 7 percent. The service sector’s share in GDP, which was about 35 percent in 1980, grew at an average annual rate of 1.3 percent. This sector overtook agriculture as the dominant sector in terms of relative contribution towards GDP, beginning mid-eighties. Currently, this sector contributes about 57 percent towards total value added in the Indian economy.

Steady growth in the service sector has been abetted by rapid TFP growth. The service sector TFP, calculated as a Solow residual, grew at a rate of 2.27 percent between 1980 and 2006. During the same sample period, TFP of the agricultural and manufacturing sectors grew at a rate of 1.03 percent and 1.59 percent respectively.
While it is unanimous that growth in the Indian economy over the last three decades has been propelled by the productivity in the service sector (Bosworth Collins and Virmani 2007 and 2008, Jones and Sahu 2008, Verma 2008), a quantitative analysis of the source(s) of this TFP growth based on micro-level data, is yet to be documented. The objective of this paper is to investigate the impact of factor (mis)allocation on service sector TFP and test the hypothesis if better factor reallocation has led to TFP gains in the service sector.

There are two distinct strands of existing literature that explain differences in TFP levels and TFP growth rates across economies. One branch of studies focuses
on differences in technology within representative firms. Howitt (2000) and Klenow and Rodriguez-Clare (2005) show that large TFP differences can emerge due to slow technology diffusion from advanced countries to countries which face policy barriers. These are models of within-firm inefficiency which show up as a lag in adoption of better technology.

Recent papers by Hsieh and Klenow (2008) and Restuccia and Rogerson (2008) take a different approach. Instead of focusing on within-firm inefficiencies, they stress on misallocation of resources across firms which has an impact on aggregate TFP. An example from Restuccia and Rogerson (2008) drives the point home. Let us assume an economy with two firms that have identical technology. One firm however, has access to cheaper credit while the other can only borrow at high interest rates from informal lenders. If both firms equate the marginal product of capital with the interest rate, then the marginal product of capital for the firm with access to cheaper credit would be lower than the marginal product of the firm that has no access to the formal lending market. This inequality in marginal product of capital across firms is a clear case of capital misallocation. Ideally, resources should flow from the firm with a lower productivity to a firm with higher levels of productivity. This misallocation of capital results in low aggregate output per worker and TFP (Hsieh and Klenow, 2008).

at the firm-level, they account for the extent of misallocation of resources in the manufacturing sectors in China and India and its effect on each country’s level of output.

Economic policies and inefficient institutions are two potential sources of resource misallocation. In India for example, 90 percent of the workforce belong to the informal sector and this drives up the labor cost for the organized sector. Although the informal sector is less productive compared to its formal counterpart, the lower labor costs in the former, due to absence of minimum-wage laws, allows the sector to thrive. Lewis (2004) cites some case studies conducted by the McKinsey Global Institute for countries where informal labor market exists.

Following Hsieh and Klenow (2008), I build a monopolistic competition model with heterogenous firms. The service sector consists of distinct industries based on their economic activities and each industry includes several firms, each producing differentiated goods. Firms differ from one another due to their levels of productivity and also due to varying levels of output and capital distortions. These distortions are modelled as deviations from first-order conditions as in Chari et al. (2007) and denote misallocation of resources. Inefficient allocation of resources has adverse impact on firm-level productivity and subsequently on sectoral productivity. I use company-level data to account for the extent of misallocation of resources in India’s service sector during 1991-2005. I further analyze the gains in TFP when capital and labor are hypothetically reallocated to equalize marginal products. My results indicate that the extent of resource misallocation in service sector has declined since the economic reforms in 1991. Due to improved resource allocation, the information and technology
(IT) industry attained a TFP level which is almost 85 percent of its efficient TFP. The communication industry, which operated at a mere 7 percent of its efficient TFP level in 1991, sprinted to almost 41 percent of its efficient TFP level by 2005. Incidentally, both IT and communication industries were the highest growing industries in the service sector.

The rest of the paper proceeds as follows. Section 3.2 reviews some studies that attempt to explain the observed growth trends in India’s service sector. Section 3.3 develops the monopolistic competition model with heterogenous producers. Section 3.4 discusses the data used for the analyses. Company-level data is aggregated to arrive at industry-level figures and comparisons with economy-wide macro-level data are done in Section 3.5. Section 3.6 describes how the model’s distortions are measured and parameters are calibrated. Section 3.7 presents the analyses based on factor misallocation and its impact on service sector TFP in India. Section 3.8 concludes.

### 3.2 Explanations for Rapid Growth of Service Sector Productivity in India

A set of policy reforms during the economic liberalization in 1991 have had significant impact on service sector’s TFP. Some important policy reforms included tariff reductions, reduction in export controls, removal of quotas, entry of foreign direct investment or FDI in some sectors and deregulation and privatization in certain industrial and service sectors.
3.2.1 Trade liberalization

Prior to 1991, India had very high tariff rates and about 439 items were subject to export controls. In 1992, this number was brought down to about 296 (Panagariya, 2004). Post-reforms, tariffs were reduced, export controls were relaxed, quota system and import licensing were dismantled. World Bank (2004) reports that the average tariff in India in 2002-03 was still high at 35 percent.

Although the Indian economy opened up significantly after 1991, Rodrik and Subramanian (2004) based on the coefficient of openness, conclude that India became a "normal" trader only by 2000.

By 2003, service sector exports were about 8 percent of services’ GDP and about 4 percent of aggregate GDP. Verma (2008) accounts for an open-economy general equilibrium model for India and concludes that export-led service sector growth in India is not a tenable hypothesis.

3.2.2 Role of foreign demand

Although trade in services has increased world-wide, Gordon and Gupta (2004) find very little evidence to link this with India’s service sector growth. Using input-output coefficients, they figure that the contribution of exports to annual average services growth was about 0.2 percentage points 0.6 percentage points in the 1980s and 1990s respectively. However, with rapid rise in IT exports, they expect this component to become significant over time.
3.2.3 FDI in services

Inflow of foreign capital and foreign technology spillover to domestic firms, are two potential reasons tied to rapid TFP growth in the service sector. Gordon and Gupta (2004) find a strong relation between the cumulative growth of FDI and service sector growth in 1990, albeit it comes with a caveat that the study is based on a highly aggregated data and the direction of causation is not clear \textit{a priori}.

Although the service sector has been attracting significant amount of FDI, especially in the telecommunications industry, the ratio of FDI to India’s GDP is very small. During 1991-2002, the cumulative share of service sector FDI inflows in service sector GDP was a mere 0.3 and it later dropped to 0.2 percent by 2003 (Handbook of Industrial Policy and Statistics, 2003-05). Thus, small share of service sector FDI cannot explain the dramatic rise in service sector output and TFP post 1991.

3.2.4 Education

The service sector is intensive in human capital. Bosworth et al. (2007) include human capital measured by education in their growth accounting exercise. For the period 1980-2004, their results indicate that the average annual growth of education as a factor of production in the service sector is 0.4 percent and accounts 14 percent of services’ output growth. Their study also indicates a shortfall of skilled labor in the near future in absence of reforms.

The Yashpal Committee Report (2009) has made a number of recommendations for reforms in higher education. The Ministry of Human Resources is planning to
make primary education more accessible and might change the school leaving examination structure for all states.

With reforms in the education sector yet to gain momentum, accelerated TFP growth in the service sector cannot be attributed to education alone.

### 3.2.5 Deregulation and privatization

Prior to the economic reforms in 1991, banking, insurance and telecommunication sectors were monopolized by the government. Following the liberalization in 1991, some industries were deregulated and private sector participation was allowed. Although some reforms in the banking and telecommunication sectors were initiated in early 1980s, it was more robust in 1991.

Banking sector was opened up and private banks were allowed to operate, following the recommendations of the Narasimhan Committee in 1991-92.

Insurance, which was a state monopoly till 1991, permitted private players under the aegis of the Insurance Regulatory and Development Authority established in the same year.

Telecommunications too, was a state monopoly till 1991. Due to the National Telecommunications Policy in 1994, private telecom operators, both domestic and foreign, were allowed to provide basic landline and cellular services.

Amongst all the competing explanations for India’s rapid service sector growth presented here, deregulation and privatization seem to be the foremost contender. With increased private sector participation, both domestic and foreign, this translates
to more firms in the service sector. Deregulation reflects resource mobility across firms and industries within the service sector. Although the following theoretical model does not explicitly account for these two aspects of liberalization, the implications of these policies are latent.

3.3 The Model

The effect of resource misallocation on aggregate TFP is captured in a monopolistic competition framework with heterogenous firms. Firms differ from one another due to their efficiency levels (as in Melitz, 2003) and also due to varying levels of output and capital distortions (as in Hsieh and Klenow, 2008).

In the service sector, a single final good $Y$ is produced by a representative firm in a perfectly competitive final output market. There are $S$ industries within the service sector and each industry produces output $Y_s$. The representative firm combines the output from each industry using a Cobb-Douglas production technology:

$$Y = A \prod_{s=1}^{S} Y_s^{\theta_s},$$

where: $A$ denotes the aggregate shifter and $\theta_s$ denotes the share of each industry in the service sector such that $\sum_{s=1}^{S} \theta_s = 1$.

Profit maximization by this representative producer gives sectoral share $\theta_s = \frac{P_S Y_s}{P Y}$, where $P_S$ is the price of output in industry $S$. The final good is the numeraire and hence $P = 1$. The share of each industry within the service sector is determined by its revenue share.
Industry output $Y_s$ is produced using $M_s$ differentiated products and a CES production technology:

$$Y_s = \left[ \sum_{i=1}^{M_s} Y_{si}^{\frac{\sigma}{\sigma-1}} \right]^{\frac{\sigma-1}{\sigma}},$$

where: $Y_{si}$ denotes the output of firm $i$ within industry $S$ and $\sigma$ denotes the elasticity of substitution.

Each firm produces a differentiated product using a Cobb-Douglas production technology that combines firm-specific TFP ($A_{si}$), capital ($K_{si}$) and labor ($L_{si}$):

$$Y_{si} = A_{si}K_{si}^{\alpha_s}L_{si}^{1-\alpha_s}. \quad (3)$$

Capital share ($\alpha_s$) and labor share ($1 - \alpha_s$) are industry-specific and not firm-specific. Thus, the factor shares are allowed to vary across industries within the service sector, but not across firms within each industry.

Each firm maximizes profit given by:

$$\Pi_{si} = (1 - \tau_{Y_{si}})P_{si}Y_{si} - wL_{si} - (1 + \tau_{K_{si}})RK_{si}, \quad (4)$$

where $P_{si}$ is the price of the differentiated good produced by each firm; $w$ and $R$ are the real wages and rental rates; $\tau_{Y_{si}}$ and $\tau_{K_{si}}$ are firm-specific output and capital distortions respectively. $\tau_Y$ denotes distortions that increase the marginal products of labor and capital by the same proportion. For example, $\tau_Y$ might be high for firms that face restrictive policies like caps on capacity utilization, licensing, high transportation costs etc. $\tau_K$ is distortions in capital relative to labor which creates a
wedge between the marginal productivity of the two factors of production. $\tau_K$ would be high for firms that do not get access to credit, but low for firms with access to cheap credit. Formally, $\tau_Y$ and $\tau_K$ are modelled as subsidies/taxes as in Chari et al. (2007) and Mulligan (2005).

The first order condition for profit maximization yields the price of the differentiated good $P_{si}$ produced by each firm. Due to monopolistic competition, $P_{si}$ is a fixed markup over its marginal cost:

$$P_{si} = \frac{\sigma}{\sigma - 1} \left( \frac{R}{\alpha_s} \right)^{\alpha_s} \left( \frac{w}{1 - \alpha_s} \right)^{1 - \alpha_s} \frac{(1 + \tau_{Ksi})^{\alpha_s}}{A_{si}(1 - \tau_{Ysi})}$$

Combining the expression for $P_{si}$ with the cost-minimization problem of each firm yields the capital-labor ratio, labor allocation and output:

$$\frac{K_{si}}{L_{si}} = \frac{\alpha_s}{1 - \alpha_s} \cdot \frac{w}{R} \cdot \frac{1}{1 + \tau_{Ksi}},$$

$$L_{si} = \frac{P_{si}Y_{si}}{A_{si}} \left[ \frac{\sigma}{\sigma - 1} \cdot \left( \frac{w}{1 - \alpha_s} \right)^{1 - \alpha_s} \left( \frac{R}{\alpha_s} \right)^{\alpha_s} \frac{(1 + \tau_{Ksi})^{\alpha_s}}{A_{si}(1 - \tau_{Ysi})} \right]^{-\sigma},$$

$$Y_{si} = P_{si}^\sigma Y_{si} \left[ \frac{\sigma}{\sigma - 1} \cdot \left( \frac{w}{1 - \alpha_s} \right)^{1 - \alpha_s} \left( \frac{R}{\alpha_s} \right)^{\alpha_s} \frac{(1 + \tau_{Ksi})^{\alpha_s}}{A_{si}(1 - \tau_{Ysi})} \right]^{-\sigma}.$$
firms depend not only on firm-specific TFP levels, but also on the capital and output distortions they face. To the extent resource allocation is driven by distortions rather than firm TFP, this will result in differences in the marginal revenue products of labor and capital across firms (Hsieh and Klenow, 2008).

The marginal revenue product of labor and capital are proportional to revenue per worker and revenue-capital ratio respectively:

$$MRP_L = \frac{\partial R_{si}}{\partial Y_{si}} \cdot \frac{\partial Y_{si}}{\partial L_{si}}, \text{where } R_{si} \text{ is the firm revenue}$$  \hspace{1cm} (9a)

$$= (1 - \alpha_s) \cdot \frac{\sigma}{\sigma - 1} \cdot \frac{P_{si}Y_{si}}{L_{si}} = w \cdot \frac{1}{1 - \tau_{Y_{si}}},$$  \hspace{1cm} (9b)

$$MRP_K = \frac{\sigma}{\sigma - 1} \cdot \frac{P_{si}Y_{si}}{K_{si}} = R \cdot \frac{1 + \tau_{K_{si}}}{1 - \tau_{Y_{si}}}.$$  \hspace{1cm} (10)

In absence of distortions, the marginal revenue products of labor and capital are same across all firms within an industry. Hence, in a frictionless economy, resource allocation is single-handedly driven by firm-specific TFP levels. But in presence of distortions, the after-tax marginal revenue products of capital and labor are equalized across firms. The before-tax marginal revenue products must be higher in firms that face disincentives and can be lower in firms that benefit from subsidies.
3.3.1 Aggregation

This key relation between resource (mis)allocation and productivity at the firm-level can now be translated to the sectoral level. To derive the expression for aggregate TFP as a function of firm-level misallocation of resources, I derive the equilibrium allocation of resources across sector by aggregating firm-level demands for the two factor inputs. Manipulating equation (7) yields:

\[
\frac{\sigma w}{\sigma - 1} \cdot \frac{\theta_s L_s}{P_s Y_s} = (1 - \alpha_s)\theta_s \left[ \sum_{i=1}^{M_s} (1 - \tau_{Y,si}) \left( \frac{P_{si} Y_{si}}{P_s Y_s} \right) \right]. \tag{11}
\]

Summing over equation (11) gives:

\[
\frac{\sigma w}{\sigma - 1} \cdot \frac{L}{P Y} = \sum_{s=1}^{S} (1 - \alpha_s)\theta_s \left[ \sum_{i=1}^{M_s} (1 - \tau_{Y,si}) \left( \frac{P_{si} Y_{si}}{P_s Y_s} \right) \right]. \tag{12}
\]

Equilibrium quantity of labor for each industry \( S \) is obtained by dividing equation (11) by equation (12):

\[
L_s = \sum_{i=1}^{M_s} L_{si}, \tag{13}
\]

\[
L_s = L \cdot \frac{(1 - \alpha_s)\theta_s / MRPL_s}{\sum_{s=1}^{S} (1 - \alpha_s)\theta_s / MRPL_s}. \tag{14}
\]
Similarly, industry-level equilibrium quantity of capital is:

\[ K_s = \sum_{i=1}^{M_s} K_{si}, \]  
\[ K_s = K \frac{\alpha_s \theta_s / \text{MRPK}_s}{\sum_{s=1}^{S} \alpha_s \theta_s / \text{MRPK}_s}, \]  

where \( L \) and \( K \) represent aggregate supply of labor and capital while \( \text{MRPL}_s \) and \( \text{MRPK}_s \) denote the weighted average of the value of marginal product of labor and capital in an industry.

Combining equation (1) with equations (14) and (16) gives the aggregate output for the service sector as a function of industry TFP, \( K_s \) and \( L_s \):

\[ Y = A \prod_{s=1}^{S} \left( \text{TFP}_s K_s^{\alpha_s} L_s^{1-\alpha_s} \right)^{\theta_s}. \]  

The next task is to further decompose industry-specific TFP \( \text{TFP}_s \) into two parts; one part due to each individual firm’s productivity or \( A_{si} \) and another due to firm-specific distortions \( \tau_{Y_{si}} \) and \( \tau_{K_{si}} \). In doing so, a distinction between a firm’s “revenue productivity” \( \text{TFPR}_{si} \) and “physical productivity” \( \text{TFPQ}_{si} \) is made.

Broadly speaking, these terms are defined as:
\[ TFPQ_{si} = A_{si} = \frac{Y_{si}}{K_{si}^{\alpha_s} (wL_{si})^{1-\alpha_s}}, \]  
\[ TFPR_{si} = P_{si} A_{si} = \frac{P_{si} Y_{si}}{K_{si}^{\alpha_s} (wL_{si})^{1-\alpha_s}}, \]

\[ = \left( \frac{R}{\alpha_s} \right)^{\alpha_s} \left( \frac{1}{1 - \alpha_s} \right)^{1-\alpha_s} \frac{(1 + \tau K_{si})^{\alpha_s}}{1 - \tau Y_{si}}, \]

with the last equality following from equation (5). In absence of any capital and/or output distortions, \( TFPR_{si} \) is the same for all firms within an industry. If there are no distortions in the sector, then more productive firms with higher \( TFPQ \) should attract more labor and capital to the point where higher output results in a lower price and the exact same TFPR as at smaller firms (Hsieh and Klenow, 2008). This is due to the fact that a firm’s output price is inversely related with its physical productivity. Firms with higher productivity incur lower marginal costs thereby charging lower prices.

However, in presence of distortions, \( TFPR_{si} \) varies across firms. Using equations (9b) and (10), \( TFPR_{si} \) is proportional to a geometric mean of the firm’s marginal revenue products of capital and labor. \( TFPR_{s} \) or revenue productivity for a particular sector is a geometric mean of the average marginal products of labor and capital in that sector.

\[ TFPR_{si} = \frac{\sigma}{\sigma - 1} \left( \frac{MRPK_{si}}{\alpha_s} \right)^{\alpha_s} \left( \frac{MRPL_{si}}{w(1 - \alpha_s)} \right)^{1-\alpha_s}, \]
Using the above equations for $T F P R_{si}$ and $T F P R_s$, industry-specific TFP ($T F P_s$) can be further decomposed as:

$$
T F P_s = \left[ \sum_{i=1}^{M_s} \left( A_{si} \frac{T F P R_s}{T F P R_{si}} \right)^{\sigma-1} \right]^{1/(\sigma-1)}.
$$

(23)

Clearly, if there are no distortions, then the term $T F P R_{si}$ disappears. Therefore, in absence of distortions, by equalizing marginal products across firms, $T F P_s$ is an aggregation of productivity of individual firms denoted by $\overline{A}_s$ where:

$$
\overline{A}_s = \left( \sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right)^{\frac{1}{\sigma-1}}.
$$

(24)

Assuming $T F P R$ and $T F P Q$ are jointly log-normally distributed, industry-specific $T F P$ can be expressed as:

$$
\log T F P_s = \log T F P R_s + \frac{1}{\sigma - 1} \log \left( \sum_{i=1}^{M_s} A_{si}^{\sigma-1} \right) - \frac{\sigma}{2} \text{var}(\log T F P R_{si}).
$$

(25)

Thus, greater dispersion in firm’s revenue productivity reduces the sector’s productivity.
3.4 Data

Company-level data for the Indian service sector have been obtained from the Prowess database provided by the Center for Monitoring Indian Economy (CMIE). The Prowess database contains detailed characteristics of all publicly listed companies in India.

I use the annual data for the service sector companies based on their Standard Industrial Classification (SIC) codes, from 1991 through 2005. The data include: gross income, gross fixed assets, capital expenses, labor compensation, company ownership and year of induction of the company in stock-market listings.

Data on gross income include income from sales, income from financial services and other income. Since calculation of firm-specific distortions, which show up as subsidies/taxes, is of primary interest, net income has not been considered.

Compensation to employees include payments made in cash or kind by a company to its workers. It includes salaries, bonus, contribution towards provident funds, staff training expenses, arrears, reimbursements etc. Company employment figures are very spotty, hence compensation to employees is used as a proxy for employment. In a crude sense, labor compensation variable also controls for labor quality.

Capital data is obtained from book value of gross fixed assets of each company.

Companies are classified based on the type of ownership. Public companies are owned either by the central government, by the state government or jointly owned by the central and state governments. Private companies have domestic ownership or foreign ownership. Some companies have joint public-private ownership.
The age of the company is calculated from the year of its induction in stock-market listings. Thus, the year of entry of each company is known. However, exit information of a company cannot be figured out from the data.

Each company is distinguished by its corresponding SIC code (2004) based on its economic activity. This enables me to aggregate the companies under the following 2-digit categories within the service sector.
<table>
<thead>
<tr>
<th>2-digit SIC code</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>51</td>
<td>Wholesale Trade</td>
</tr>
<tr>
<td>52</td>
<td>Retail Trade</td>
</tr>
<tr>
<td>55</td>
<td>Hotels and Restaurants</td>
</tr>
<tr>
<td>62</td>
<td>Air, Land and Water Transport</td>
</tr>
<tr>
<td>64</td>
<td>Post and Telecom</td>
</tr>
<tr>
<td>65</td>
<td>Finance, Insurance and Auxiliary Financial Intermediation</td>
</tr>
<tr>
<td>70</td>
<td>Real Estate Activities</td>
</tr>
<tr>
<td>71</td>
<td>Renting of Machinery and Other Businesses</td>
</tr>
<tr>
<td>72</td>
<td>Computer and Related Activities</td>
</tr>
<tr>
<td>75</td>
<td>Public Administration and Defense</td>
</tr>
<tr>
<td>80</td>
<td>Education</td>
</tr>
<tr>
<td>85</td>
<td>Health and Social Work</td>
</tr>
<tr>
<td>91</td>
<td>Activities of Membership Organizations</td>
</tr>
<tr>
<td>92</td>
<td>Entertainment and Recreations</td>
</tr>
<tr>
<td>98</td>
<td>Other Diversified Activities</td>
</tr>
</tbody>
</table>

To make the micro-level data comparable with the economy-wide macro-level data, I compress the above-mentioned industries into four major industry heads as in the National Accounts Statistics for India. They are as follows:
3.5 Aggregation of Micro-Level Data and Comparison with Macro-Level Data

Before presenting the results based on the above model, I compile the company-level data and arrive at aggregate measures for the four broad industries within the service sector, viz. i) Trade, Hotel and Restaurant; ii) Transportation, Storage and Communications; iii) Financial, Real Estate and Business Services; and, iv) Community, Social and Government Services. Micro-level data is aggregated to the industry-level and subsequently to the sectoral-level, after making proper adjustments for sector-specific output elasticities with respect to capital and labor, and relative share...
of each industry in the service sector.

In comparing the aggregated data obtained from company-level data, with the economy-wide macro data obtained from the National Accounts Statistics, one needs to bear in mind the following caveat. Micro data from the Prowess database is not survey-based data. Since Prowess reports the data exclusively for the publicly listed companies, non-listed companies are excluded from the present analysis. Additionally, the Indian service sector is characterized by the presence of a large informal sector, which again, is not accounted for in the Prowess database. For example, a typical developing country enterprise like small local shops or groceries in temporary markets, is to be found all over India, but these do not come under the purview of the Prowess database. The economy-wide data from the National Accounts Statistics on the other hand, include all establishments belonging to both the formal and informal service sectors. Thus a discrepancy between macro data aggregated from the micro data versus macro data from the National Accounts Statistics, seems plausible.

3.5.1 Service sector output

Service sector companies included in the micro-level dataset account for almost 44 percent of the sector’s total output as in 2005. This number has increased progressively from 1991, as evident from Table 3.2. This probably signifies entry of new firms in the sector after the reforms in 1991.
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade, Hotel and Restaurants</td>
<td>6</td>
<td>23</td>
<td>33</td>
<td>41</td>
</tr>
<tr>
<td>Transportation, Storage and Communications</td>
<td>4</td>
<td>20</td>
<td>27</td>
<td>43</td>
</tr>
<tr>
<td>Financial, Real Estate and Business Services</td>
<td>12</td>
<td>31</td>
<td>81</td>
<td>86</td>
</tr>
<tr>
<td>Community, Social and Government Services</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Overall Service Sector</td>
<td>6</td>
<td>19</td>
<td>36</td>
<td>44</td>
</tr>
</tbody>
</table>

Table 3.2. Aggregation of micro-level output as % of macro-level output

Financial, real estate and business services firms account for over 85 percent of this industry’s output based on macro data in 2005. In the post-reform era, due to deregulation and privatization, several big domestic and foreign companies entered this industry. The industry for community, social services and government services captures not more than 8 percent of its aggregate macro counterpart. This is perhaps due to the fact that schools, hospitals etc., which come under the ambit of this sector, are not listed with the stock-exchange and hence not included in the micro-level dataset.

3.5.2 Service sector capital

Table 3.3 indicates that the service sector companies included in the micro-level dataset, hold almost 38 percent of aggregate economy-wide capital in 2005. This number was significantly low in 1991 and increased from 4 percent to above 25 percent
As in the case of output, the firms within the industry that includes financial and other businesses, explain almost 77 percent of the aggregate capital holding by this industry in 2005, followed by the transport and communications industry. Companies belonging to the community and other services industry, pick up negligible proportion of the industry’s aggregate capital numbers.

3.5.3 Service sector labor

Labor data from micro data is in the form of labor compensation whereas it is presented as employment numbers in the aggregate data. To make the data comparable, aggregate employment figures are converted to aggregate labor compensation. I assume that 70 percent of a firm’s net revenue (after deducting 30 percent corporate taxes from gross revenue) is paid towards wage bill.
Table 3.4 indicates that the service sector companies included in the micro-level dataset, account for almost 11 percent of aggregate economy-wide labor in 2005. As in the case of output and capital, the firms within the financial and other businesses industry, explain almost 31 percent of the aggregate employment by this industry in 2005, followed by the transport and communications industry at 13 percent.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Trade, Hotel and Restaurants</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Transportation, Storage and Communications</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Financial, Real Estate and Business Services</td>
<td>3</td>
<td>6</td>
<td>20</td>
<td>31</td>
</tr>
<tr>
<td>Community, Social and Government Services</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Overall Service Sector</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 3.4. Aggregation of micro-level labor as % of macro-level labor

Almost 90 percent of India’s workforce belongs to the informal sector. Since the informal sector is not a part of the micro-level database used for this paper, it is not surprising that the micro-level versus macro-level labor comparison is far from satisfactory.

3.6 Calculation of distortions

In order to calculate the effects of resource misallocation on aggregate TFP, capital and output distortions are backed out from the equations in section 3.3. Before doing
that, we need to make reasonable assumptions about some parameters in the model.

Following Hsieh and Klenow (2008), the rental price of capital (without distortions) \( R \) is set at 0.10. This is based on the number obtained when the real rate of interest is 5 percent and the rate of depreciation is 5 percent. The real rate of interest for the Indian economy has hovered in the range of 5 percent – 10 percent during the time period considered in this paper. The actual cost of capital faced by firm \( i \) in an industry \( s \) is denoted by \((1 + \tau_{Ksi})R\). Thus, in presence of distortions, the rental price of capital differs from 10 percent.

The elasticity of substitution \( \sigma \) is set at 3. This value lies in a range between 3 and 10 in the trade and industrial organization literatures (Broda and Weinstein 2006, Hendel and Nevo 2006). This is a conservative estimate following Hsieh and Klenow (2008).

The share of capital \( \alpha_s \) and labor \( 1 - \alpha_s \) are industry-specific and do not vary across firms within an industry. \( \alpha_s \) is estimated as elasticity of output with respect to capital for each industry from a pooled dataset. The average value of \( \alpha_s \) for the entire service sector is approximately 0.3.

Based on the firm-level data and the parameter values, output distortions, capital distortions, and firm-level productivity are inferred as follows:

\[
1 - \tau_{Y_{si}} = \frac{\sigma}{\sigma - 1} \cdot \frac{wL_{si}}{(1 - \alpha_s)P_{si}Y_{si}}.
\]

The expression for output distortion in equation (26) is derived from equations (5) and (6). Distortion in output is detected when labor’s share is low compared to
what one would get from the industry elasticity of output with respect to labor. It is to be noted that we consider the gross revenue earned by the firm which does not contain any explicit subsidy/taxes.

The output distortions for the entire service sector during 1991-2005, is plotted in Figure 3.1. Both data and a non-liner trend fitted to the data, show a declining trend in output distortions over the years. Recall that output distortions are due to factors that affect marginal products of both labor and capital simultaneously. One can infer that the post-1991 reforms created a favorable environment for the service sector. Emphasis on infrastructure-related development projects, increased foreign participation, less government intervention in the most thriving industries like IT, banning work stoppages etc., have affected both capital and labor productivity positively.

![Image of Figure 3.1](image-url)

**Figure 3.1.** Output distortions in the service sector in India
Figure 3.2 presents a closer view of output distortions across all service industries. By and large, all industries exhibit a downward trend in output distortions during 1991-2005. The IT industry shows the sharpest decline in output distortions. It can be concluded that amongst all service related industries, the reforms package in 1991 has been most conducive for the IT industry as far as decline in output distortions in concerned.

The floodgates were opened in 1991, which allowed the entry of foreign IT companies in India. Liberalization of imports allowed Indian IT firms to obtain inputs for their own production of software and services. Existing supply of skilled labor facilitated the process of rapid technology transfer and adoption. India’s stock of IT professionals is currently estimated at about 2 million (NASSCOM, 2009). A large
english-speaking population of young graduates was absorbed in the new-born IT-enabled services like call-centers and medical transcriptions. Despite the growth of this industry, telecommunications bottlenecks and shortage of skilled professionals, continue to exist (Singh, 2004).

Another way to interpret the output distortions, is in terms of revenue taxes. Equation (4) denotes that lower capital distortions lead to higher net revenues\(^1\). Falling output distortions in all industries indicate a lowering of corporate income taxes. This conclusion is in sync with the available empirical evidence. Based on the report of the Tax Reform Committee in 1991, the government implemented some of its recommendations in phases. In the case of corporate income taxes, the rates were progressively reduced on both domestic and foreign companies to 35 percent and 48 percent respectively (Rao, 2000). Besides depreciation allowances and exemptions for exporters, generous tax holidays and preferences were given for investment in sectors like housing, medical equipment, software businesses etc. (Rao, 2000). Drastic reduction in both the average and peak tariff rates were made. Average and peak tariff rates dropped from 125 percent and 355 percent respectively in 1991 to 25 percent and 40 percent by 1998 (Rao, 2000). Although the corporate-incomes tax rate is presently at about 55 percent, the government continues to give a host of tax-related incentives to the service sector like tax-holidays upstart companies in telecommunications, new companies in backward areas etc., which lowers the effective tax rate.

Capital distortion in equation (27) is obtained by rearranging equation (6).

\(^1\)The distortions, proxied as tax rates in the model, are strictly accounting figures. They might not correspond to the actual tax rates in an economy.
\[ 1 + \tau_{Ksi} = \frac{\alpha_s}{1 - \alpha_s} \cdot \frac{wL_{si}}{RK_{si}}. \quad (27) \]

Capital distortion (with respect to labor) signifies a divergence between the marginal products of the inputs used in production. In presence of distortions, the ratio of the factor shares is not equal to the ratio of output elasticities with respect to labor and capital. Thus a low capital distortion would show up as a high labor distortion in this model.

Figure 3.3 shows that the trend in capital distortions for the overall service sector has been declining since 1991. Recall that the way we have modelled capital distortions or \( \tau_{Ksi} \) in equation (4), a negative value of \( \tau_{Ksi} \) denotes less capital expenses. At the same time, since \( \tau_{Ksi} \) is capital distortion relative to labor, a decreasing trend in capital distortion implies an increasing trend in labor distortions. Jones and Sahu (2008) find the exact similar labor-capital distortions pattern while accounting for service sector growth factors in a general equilibrium model.

Capital distortions, which reflect capital mobility relative to labor mobility across firms, might have diminished primarily on account of trade liberalization, deregulation and privatization. Conversely, archaic labor laws, stringent labor market regulations and lack of sufficient labor market reforms (Basu and Maerterns, 2007) seem responsible for worsening labor distortions. Studies based on labor market regulations and worker productivity in the manufacturing sector in India suggest an inverse relation between pro-worker regulation and firm-productivity (Besley and Burgess, 2004). Kochar et al (2006) find that restrictive labor regulations not only take toll on
firm productivity, but they also keep away potential market entrants. The Industrial Disputes Act of 1947, makes it difficult for firms employing more than 100 people to lay-off workers. In today’s globalized world, with volatile and shifting demand, firms have responded to this by maintaining a low workforce (Basu and Maerterns, 2007). In some Indian states like West Bengal, trade union activities with strong support from the ruling government, have resulted in deterioration of labor distortions over the years (Lahiri and Yi, 2009). All in all, due to lack of sincere labor market reforms, labor distortions have worsened across all sectors in India including the service sector.

![Capital distortions](image)

**Figure 3.3. Capital distortions in the service sector in India**

The capital distortion patterns for each individual service industry, presents an interesting picture (Figure 3.4) . With the exception of the IT industry and education industry, all other industries exhibit a declining trend in capital distortions. Communication industry registered steady decline in capital distortions possibly due
to its deregulation starting 1991.

![Graphs showing trends in various sectors]

Figure 3.4. Capital distortions in service sector industries

The capital distortions trend in the IT industry is intriguing. During 1991-1998, capital distortions followed a downward trend, in tune with the pattern of the rest of the sector. Post 1998 however, this trend has reversed, implying that the relative distortions in capital have been worsening. I present my own thoughts towards explaining this peculiar trend.

As a part of import-substituting policies during the post-independence era in 1950s, state-controlled heavy industries were established. Technical education was given due emphasis. The government initially set up five campuses of Indian Institute of Technology (IIT) and the institutes produced a pool of world-class engineering graduates. But due to lack of adequate employment opportunities in the domestic
market, most of them, especially software engineers, migrated to the West during 1960s and 1970s. It was only during 1977-1980, some Indian IT companies like Tata Infotech and Wipro began to surface. With the microchip revolution in the 1980s, the Indian government envisioned information technology and telecommunications as the industries of the future. The industry, which was still very much in its nascent stages till then, “took-off” beginning 1990s due to the opening up of the economy, deregulation and privatization etc., as mentioned above. This upsurge of the IT sector made more students take up engineering studies. Simultaneously, the government allowed setting up of private engineering colleges, thereby ending the monopoly of the government engineering colleges. As a result, more students gained access to the engineering colleges which was thus far restricted to the top-ranked students.

In the early years of the decade of nineties, labor market distortions in the IT industry worsened. Initially, labor employment in this sector was about 56,000 in 1990 (NASSCOM, 2006). The labor shortage persisted for some years on two possible accounts. First, it took a while for the new generation to realize that a promising sector has emerged that has tremendous growth potential. Second, upon this realization, one has to allow for 4 – 5 years for fresh graduates to arrive at the market. In other words, supply of IT professionals became steady only after 1996-1997. Within three years time, the IT employment almost doubled from 160,000 in 1996 to 284,000 in 1999 (NASSCOM, 2006). As employment continued to grow in this industry, coupled with efficient organizational management of private companies, the relative labor distortions (capital distortions) declined (increased). This is one possible explanation
for the mildly U-shaped capital distortion trendline in the IT sector.$^2$

The above reasoning ties up well with the inverse U-shaped capital distortions trendline for the education industry, if, employment in the corporate sector or the IT industry and working for the education sector are treated as substitutes.

Finally, firm-level productivity is calculated as the usual Solow residual in equation (28) with two differences.

$$A_{si} = \frac{(P_{si}Y_{si})^{\frac{\sigma}{\sigma-1}}}{K_{si}^{\alpha_s}(wL_{si})^{1-\alpha_s}}.$$  

First, Hsieh and Klenow (2008) explain that one observes each firm’s nominal output $P_{si}Y_{si}$ and not real output $Y_{si}$. Firms with higher real output must have a lower price to explain why consumers buy their goods. Thus $P_{si}Y_{si}$ is raised to the power $\frac{\sigma}{\sigma-1}$ to arrive at $Y_{si}$. Second, employment $L_{si}$ is replaced by the firm’s wage bill $wL_{si}$. This is partly due to the lack of firm-level employment data and partly to account for differences in workers’ skills and hours worked across firms.

A detailed analysis of firm-level productivity, dispersion of firm productivity from industry mean and the impact of resource misallocation, are discussed in detail in the following section.

$^2$In a way, the IT industry came into being only in 1991, following the reforms mentioned earlier. If one treats IT as a nascent industry, then in the first few years after 1991, the industry exhibited an increasing returns to scale. Tax holidays given to new IT companies during the initial years, along with relaxation of import of IT-related inputs, helped the industry to grow rapidly. However, in later years, as capital utilization reached its optimal level, the industry started exhibiting decreasing returns. Capital distortion was initially declining due to increasing returns, but as decreasing returns set in, it started showing an upward trend.
3.7 Factor Misallocation and TFP

The preceding section provided evidence on factor misallocation across firms in the service sector in India. Recall that factor misallocation gets reflected via output and capital distortions in equations (26)-(27). Both output distortions, and capital distortions relative to labor, have declined since 1991.

Inefficient allocation of resources across firms prevents resources from flowing to the most productive units. As the extent of factor misallocation in the service sector dropped in the post reform era, one can associate it with higher TFP gains. In this section, I present the empirical evidence on the relation between factor misallocation and TFP.

Tables 3.5 and 3.6 show various measures of dispersion of physical productivity or TFPQ and revenue productivity or TFPR. TFPQ is obtained from equation (18) and TFPR is calculated from equation (20). Statistics are for deviations of log deviation of firm-level TFPQ and TFPR from their respective industry means. To arrive at the overall service TFPQ and TFPR figures, all industries are weighted by their value-added shares.
The standard deviation of both TFPQ and TFPR increased after 1991. Dispersion measures based on the difference between the 75th and 25th percentiles, and, 90th and 10th percentiles, indicate a similar trend. Micro data suggests that both physical and revenue productivity of the overall service sector have become more volatile since 1991. A business cycle analysis by Jones and Sahu (2008), finds service productivity as the most dominant source of output fluctuations in India during 1980-2005. Globalization or integration of the service sector with the rest of world after 1991, might be a plausible reason for increase in physical productivity fluctuations.

Although dispersions of TFPQ and TFPR exhibit similar trends, Table 3.5 shows that TFPR has been less volatile than TFPQ. Since TFPR is TFPQ multiplied by price, only a low dispersion in prices can pare down the TFPR fluctuations. There is evidence that relative prices of the service sector have indeed declined in India after 1990 (Gordon and Gupta, 2004).

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>2.27</td>
<td>2.45</td>
<td>3.13</td>
<td>3.22</td>
</tr>
<tr>
<td>75-25</td>
<td>3.15</td>
<td>2.75</td>
<td>3.54</td>
<td>3.70</td>
</tr>
<tr>
<td>90-10</td>
<td>4.80</td>
<td>4.79</td>
<td>6.51</td>
<td>6.21</td>
</tr>
<tr>
<td>N</td>
<td>4,858</td>
<td>7,538</td>
<td>9,141</td>
<td>9,458</td>
</tr>
</tbody>
</table>

SD-Standard deviation; N-number of firms

Table 3.5. Dispersion of TFPQ
Table 3.6. Dispersion of TFPR

Since TFPR is the key variable that signifies the extent of factor misallocation, let us now take a more detailed look at its dispersion for each individual industry within the service sector.

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>0.99</td>
<td>1.06</td>
<td>1.20</td>
<td>1.32</td>
</tr>
<tr>
<td>75-25</td>
<td>1.14</td>
<td>1.16</td>
<td>1.43</td>
<td>1.53</td>
</tr>
<tr>
<td>90-10</td>
<td>2.34</td>
<td>2.44</td>
<td>2.94</td>
<td>3.15</td>
</tr>
<tr>
<td>N</td>
<td>4,858</td>
<td>7,538</td>
<td>9,141</td>
<td>9,458</td>
</tr>
</tbody>
</table>

SD—Standard deviation; N—number of firms
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale Trade</td>
<td>1.15</td>
<td>1.24</td>
<td>1.51</td>
<td>1.67</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>1.11</td>
<td>1.65</td>
<td>.</td>
<td>1.05</td>
</tr>
<tr>
<td>Hotels and Restaurants</td>
<td>0.43</td>
<td>0.55</td>
<td>0.62</td>
<td>0.66</td>
</tr>
<tr>
<td>Air, Land and Water Transport</td>
<td>0.69</td>
<td>1.17</td>
<td>0.84</td>
<td>0.97</td>
</tr>
<tr>
<td>Post and Telecom</td>
<td>1.24</td>
<td>0.90</td>
<td>0.92</td>
<td>0.80</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>0.81</td>
<td>0.93</td>
<td>1.02</td>
<td>1.17</td>
</tr>
<tr>
<td>Real Estate Activities</td>
<td>0.95</td>
<td>1.38</td>
<td>1.52</td>
<td>1.46</td>
</tr>
<tr>
<td>Other Businesses</td>
<td>0.77</td>
<td>0.72</td>
<td>0.91</td>
<td>1.14</td>
</tr>
<tr>
<td>Computer and Related Activities</td>
<td>1.01</td>
<td>0.89</td>
<td>1.09</td>
<td>1.06</td>
</tr>
<tr>
<td>Education</td>
<td>.</td>
<td>.</td>
<td>0.97</td>
<td>0.65</td>
</tr>
<tr>
<td>Health and Social Work</td>
<td>0.69</td>
<td>0.71</td>
<td>0.48</td>
<td>0.83</td>
</tr>
<tr>
<td>Activities of Membership Organizations</td>
<td>.</td>
<td>.</td>
<td>0.87</td>
<td>0.57</td>
</tr>
<tr>
<td>Entertainment and Recreations</td>
<td>.</td>
<td>1.14</td>
<td>1.20</td>
<td>1.19</td>
</tr>
<tr>
<td>Other Diversified Activities</td>
<td>0.52</td>
<td>0.71</td>
<td>0.64</td>
<td>1.54</td>
</tr>
</tbody>
</table>

Table 3.7. Standard deviation of firm-TFPR from its industry mean

Table 3.7 shows that by and large, the volatility of revenue productivity has increased for all industries with some exceptions. Deregulated industries with relatively less foreign companies, like, transport and communications, post and telecom and education, show less TFPR volatility. Industries mildly touched by reforms- health
and social service, and entertainment industries, show almost stable TFPR dispersions. Thus, fluctuations in TFPR have been only in those industries, where reforms brought in more foreign contact, either through trade or capital inflows or direct market participation.

Next, we turn our attention to factor misallocation and its impact on industry-level productivity. Equations (7) and (20) established that, to the extent resource allocation is driven by distortions rather than firm TFP, this will result in TFPR differences across firms within an industry. The actual TFP for each industry, which includes distortions or in other words resource misallocation, is calculated from equation (23). The efficient level of industry-level TFP sans any distortions or resource misallocations, is obtained from equation (24). Thus, to what extent each industry’s TFP diverges from its efficient level of TFP, is given by the ratio of equation (23)
and equation (24).

<table>
<thead>
<tr>
<th>Industry</th>
<th>1991</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale Trade</td>
<td>12.98</td>
<td>3.80</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>9.80</td>
<td>22.02</td>
</tr>
<tr>
<td>Hotels and Restaurants</td>
<td>92.04</td>
<td>92.04</td>
</tr>
<tr>
<td>Air, Land and Water Transport</td>
<td>51.82</td>
<td>52.12†</td>
</tr>
<tr>
<td>Post and Telecom</td>
<td>6.51</td>
<td>41.04</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>14.85</td>
<td>13.92</td>
</tr>
<tr>
<td>Real Estate Activities</td>
<td>13.88</td>
<td>27.89</td>
</tr>
<tr>
<td>Other Businesses</td>
<td>9.19</td>
<td></td>
</tr>
<tr>
<td>Computer and Related Activities</td>
<td>31.25</td>
<td>86.19</td>
</tr>
<tr>
<td>Education</td>
<td>5.25*</td>
<td>41.36</td>
</tr>
<tr>
<td>Health and Social Work</td>
<td>26.62</td>
<td>73.93</td>
</tr>
<tr>
<td>Activities of Membership Organizations</td>
<td>17.04*</td>
<td>38.31</td>
</tr>
<tr>
<td>Entertainment and Recreations</td>
<td>39.46*</td>
<td>43.79</td>
</tr>
<tr>
<td>Other Diversified Activities</td>
<td>57.64</td>
<td>45.97</td>
</tr>
</tbody>
</table>

* — Year 2000 value; †—Year 2007 value

Table 3.8. Actual TFP as % of efficient TFP for each industry

Table 3.8 gives the actual TFP of each industry as a percentage of its efficient TFP level for the years 1991 and 2005. With the exception of wholesale trade industry, the hotel industry, the financial sector and other diversified activities, all other industries
in the service sector narrowed down the gap between their actual and efficient TFP levels.

Hotel and restaurant attained near-efficient TFP levels in 1991 and maintained it in 2005.

The IT industry’s TFP level which was at 31 percent of its efficient level in 1991, jumped to almost 86 percent in 2005. The rapid decline in the output distortions in this sector was noted earlier. From the bidirectional movement of relative capital distortions in this sector during 1991-2005, in the wake of TFP increase, it can be concluded that decline in labor distortions played a relatively important role. As this sector is intensive in human capital, the projections of deficit of skilled manpower, might affect the TFP adversely in near future. Incidentally, business services which includes IT, was the fastest growing sector in the 1990s, with growth averaging nearly 20 percent a year (Gordon and Gupta, 2004).

The communication industry consisting of post and telecom, which had an abysmally low relative TFP level in 1991, operated at 41 percent of its efficient level in 2005. Steady decline in both output and capital distortions indicating improved resource allocation, led this improved TFP level. Communications services registered growth of 14 percent per year during the last decade (Gordon and Gupta, 2004).

In community services industry, both education and health moved closer to their respective efficient TFP levels by 2005. Banking sector, despite reforms in 1991, did not achieve much in terms of moving closer to its efficient TFP level in 2005. Although output distortions in banking declined marginally post-1991, capital distortions was almost unchanged during 1991-2005 (Figure 3.4). Thus, there was not much improve-
ment in resource reallocation leading to stagnant relative TFP levels in the banking industry.

Thus, economic reforms of 1991 seem to have pushed the IT industry, the communications industry and community services, towards their respective efficient TFP levels via decline in resource misallocation.

3.7.1 Ownership and resource misallocation

We observed a decline in the extent of resource misallocation primarily in those industries where private sector participation increased over the years. In that case, is there a systematic relation between resource misallocation and firm ownership?

Table 3.9 presents the results of regressing TFPR on firm ownership types. TFPR is in terms of log deviations from the industry means. The independent variables are dummies for central government owned firms, firms owned by state government, jointly owned plants (firms owned by both the central and state governments) and
private foreign plants. The omitted group is private domestic firms.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Govt</td>
<td>0.30</td>
<td>−0.05</td>
<td>0.22</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>(1.49)</td>
<td>(−0.39)</td>
<td>(1.71)</td>
<td>(4.92)</td>
</tr>
<tr>
<td>State Govt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Central/State</td>
<td>−0.04</td>
<td>0.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(−0.04)</td>
<td>(0.26)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Foreign</td>
<td>0.07</td>
<td>0.04</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>(0.29)</td>
<td>(0.32)</td>
<td>(−0.25)</td>
<td>(0.58)</td>
</tr>
</tbody>
</table>

Table 3.9. TFPR by ownership

Since TFPR is measured as deviation from industry mean, positive coefficient values signify higher TFPR deviation and hence higher resource misallocation relative to the privately owned domestic companies. In India, resource misallocation is worse government firms, although the results are statistically significant for the years 2000 and 2005 only. For other types of ownerships, no conclusive evidence can be inferred since the results are not statistically significant.

Similarly, there seems to be no systematic relationship between TFPQ and firm ownership. Table 3.10 shows that firm TFPQ measured as a deviation from industry

---

3The dependent variable is the deviation of log TFPR from the industry mean. The omitted group is domestic private firms. Entries are the dummy coefficients with t-statistics in parenthesis.
mean, cannot be explained solely by ownership since none of the coefficients are statistically significant.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Govt</td>
<td>-0.46</td>
<td>-0.18</td>
<td>0.33</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>(-1.24)</td>
<td>(-0.80)</td>
<td>(1.27)</td>
<td>(0.87)</td>
</tr>
<tr>
<td>State Govt</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joint Central/State</td>
<td>2.48</td>
<td>-6.68</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.44)</td>
<td>(-0.09)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private Foreign</td>
<td>-0.15</td>
<td>0.27</td>
<td>0.40</td>
<td>-5.47</td>
</tr>
<tr>
<td></td>
<td>(-0.34)</td>
<td>(1.20)</td>
<td>(1.87)</td>
<td>(-0.86)</td>
</tr>
</tbody>
</table>

Table 3.10. TFPQ by ownership

Thus, deviation in firm-level TFPR and TFPQ (from their industry means) cannot be explained by the ownership factor. Therefore the errors are classical in the sense of being orthogonal to the truth and other reported variables.

3.7.2 Other factors affecting resource misallocation

The main premise of this paper is that resource misallocation leads to variability in TFPR across firms within similar industries. Are there other factors that might

---

\(^4\)The dependent variable is the deviation of log TFPQ from the industry mean. The omitted group is domestic private firms. Entries are the dummy coefficients with t-statistics in parenthesis.
To answer this, I consider the cumulative percentage share of within-industry TFPR explained by factors like firm size, firm ownership and firm age. Dummies for firm size and firm age are based on their quartile values. Ownership dummy has four categories as mentioned in the preceding subsection. The results are pooled for all years and are cumulative in that “ownership” contains both firm size and ownership and “age” contains firm size, ownership and firm age.

<table>
<thead>
<tr>
<th>Year</th>
<th>Firm size</th>
<th>Ownership</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>1.6</td>
<td>2.5</td>
<td>5.9</td>
</tr>
<tr>
<td>1995</td>
<td>4.8</td>
<td>5.3</td>
<td>9.0</td>
</tr>
<tr>
<td>2000</td>
<td>3.5</td>
<td>3.7</td>
<td>4.2</td>
</tr>
<tr>
<td>2005</td>
<td>7.0</td>
<td>7.1</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Table 3.11. Cumulative % sources of TFPR variation within industries

Table 3.11 indicates that all three sets of dummies together account for less than 10 percent of the deviation of service sector TFPR in India. Thus, one can continue to assume that within-industry TFPR divergence is primarily due to output and capital distortions reflecting resource misallocation.

### 3.8 Conclusion

Service sector-led growth in India has been an active area of empirical research in recent times. Existing literature indicates rapid increase in service TFP as the
dominant source of service sector growth.

This paper uses micro data on service sector companies to investigate the possible impact of reduction of factor misallocation on TFP improvements in India during 1991-2005. Using a monopolistic competition model, it is assumed that presence of capital and output distortions create differences in marginal products of labor and capital across firms within service sector industries. Results indicate that the extent of resource misallocation in service sector has declined since the economic reforms in 1991. Due to improved resource allocation, the IT industry attained a TFP level which is almost 85 percent of its efficient TFP. The communication industry, which was operating at a mere 7 percent of its efficient TFP level in 1991, sprinted to almost 41 percent of its efficient TFP level by 2005. Incidentally, both IT and communication industries registered the highest growth rates in output during the sample period.

The results require caveats. The database used for this paper, includes only publicly listed companies. Thus non-listed companies and informal sector activities are not included in the analysis. Although I have established that the micro data trends follow the broad macro data trends for the service sector, more robust results can be obtained from a more comprehensive dataset. Finally, policy reforms, factor allocation, and their impact on firm entry and exit can be considered for future research.
4 Liberalization and Service Sector Performance in India

4.1 Introduction

This paper attempts to investigate the effects of economic reforms on service sector’s performance in India. Liberalization policies for services have been industry-specific and have occurred in several waves. The degree and type of reforms too have varied across industries.

In particular, this paper analyzes the extent to which liberalization has affected performance measures such as productivity, output and profits, and how the economic performances vary with the technological capabilities of firms in the service sector. Two measures of liberalization are considered for this task. Following Aghion and Burgess (2003), I model liberalization as an increase in probability in firm entry. According to their premise, reduction in entry barriers has a positive effect on economic performance for firms that are initially closer to the technological frontier. Firms operating far below their production frontier would perish if new firms enter the industry. Thus, liberalization magnifies the initial differences in productivity.

A second measure of liberalization is based on the “services policy reform index” (SPRI) created by Arnold and others (2008). This index is time varying and captures the degree of reforms in each service industry. It is expected that higher economic performance is associated with a higher degree of reform in the service sector. Additionally, by combining a firm’s distance from the frontier in the pre-reform years, with
the degree of liberalization of its parent industry, I find firms closer to the frontier in
the pre-reform phase performing better with increased reforms relative to those far
below the frontier.

The impact of liberalization on firm performance also depends upon economic
institutions like labor regulations. Labor regulations in India vary across regions or
states and thus affect incentives for firms to invest and innovate. I use the Besley-
Burgess labor index constructed for the Indian states to investigate the relationship
between service reforms and firm location. No clear relation between labor regulation
and service reforms is found for India. This contrasts with Aghion et al.’s (2008)
findings for the manufacturing sectors where manufacturers in states with pro-labor
regulations have performed less well.

I build a Schumpeterian model of growth with entry threat and innovations. A
cOMPANY-LEVEL PANEL DATASET FOR INDIA SPANNING FROM 1991-2005 IS USED TO TEST THE
main theoretical predictions of the model. Methodologically, my paper bears close
resemblance with Aghion et al. (2008) who provide evidence on the effects of dis-
mantling of the License Raj in the Indian manufacturing industries. The effects are
found to be unequal across Indian states with different labor market regulations. In
particular, they find that following delicensing, industries located in the states with
pro-employer labor market institutions (as categorized by Besley and Burgess, 2004)
grew more quickly than those in the pro-labor environments.

The ensuing sections present a theoretical model and an empirical framework for
testing the relationship between liberalization and economic performance of India’s
service sector. Section 4.2 provides a brief outline of the significant reforms carried
out in the major service industries. Labor market regulations across different states in India and how they have been coded, are explained in Section 4.3. Section 4.4 lays out a theoretical model which captures the relationship between potential firm entry and its effect on the economic performance of the incumbent firms. Section 4.5 presents the panel estimations to test the model proposition. Data used for estimation purposes is discussed in Section 4.6. Section 4.7 discusses the main findings of this paper and section 4.8 concludes.

4.2 Services liberalization in India

In the 1980s, the service sector in India was dominated by state enterprises, there were restrictions on entry by private domestic and foreign providers, and prices of services were largely fixed by the government (World Bank, 2004). The 1990s saw significant “pro-market” reforms in an attempt to achieve greater efficiency in firm operations.

The pace of policy reforms has, however, varied across sectors and been determined primarily by political considerations (Hoekman, Mattoo and Sapir, 2007). Sectors in which privatization and competition would mean restructuring and large-scale layoffs were slower to benefit from the reforms than those in which the incumbents could remain profitable and employment would not decline even as foreign and domestic competitors entered the market. Reforms were also slower to materialize where it was feared that they could cause a reduction in access to services to the poor or rural communities. (Arnold et al., 2008).
Industries in the service sector fall under three categories: significantly liberalized, moderately liberalized and closed. Figure 4.1 lists the industries based on their type of reform. I discuss briefly the major policy shifts in some of the key industries.


Figure 4.1. Growth rates of services output by level of liberalization

4.2.1 Business services (IT)

India’s software industry begun in 1974 but initially operated under odd conditions. Local markets were absent and Mumbai-based conglomerates began the industry by sending programmers to work for global IT firms overseas. They succeeded by exploiting the new global market opportunity, while protected from transnational corporations and startups by policy. The telecommunications infrastructure was monopolized by the government, thereby pushing up costs which only a few firms could afford. The protected environment restricted the growth of project management and domain skills so that despite presence of a large pool of qualified programmers, the
industry could not grow in value-addition (Dossani, 2005). High tariffs on imported hardware and software prevented small private firms from entering the market and the IT industry was characterized by the presence of a handful of big players.

The “microchip” revolution of the 1980s convinced the ruling prime minister Indira Gandhi and her successor Rajiv Gandhi to gradually open up the IT and telecommunications sectors. Satellite links made the disembodied export of software possible. The first link was set up in 1985 and the government did not allow private links (Desai, 2003). The government insisted on retaining its monopoly in telecommunications and since the rates offered by the Department of Telecommunications were exorbitant. The newly set up Department of Electronics broke this impasse in 1991 by creating Software Technology Parks of India (STPI). STPI set up technology parks in different cities, each of which provided satellite links to be used by firms with wireless connections to them. In 1993, the government began to allow private dedicated links as well (Desai, 2003).

Another significant change was in the import regime. In the 1992 import policy, computers were freed from import licensing and import duties on them were reduced in the same year.

Thus, the two changes- satellites and import liberalization, enhanced rapid growth in the Indian IT and IT-enabled services (Desai, 2003).

4.2.2 Telecommunications

Prior to 1992, the telecommunications sector was solely operated by the central government. Starting 1992, the government began to issue select operating licenses
to private providers. Cellular service began in 1994 and the government announced the National Telecom Policy which improved the environment for private investment in the telecom sector. In 2002, the government fully opened the long distance sector of the telecom industry to private competition and eliminated all restrictions on the number of service providers, except in areas where limits were dictated by the availability of spectrum. Foreign ownership limitations were also significantly relaxed and now range from 74 percent to 100 percent across different segments (Arnold et al., 2008).

4.2.3 Banking

The banking sector was nationalized in 1969 with an objective to provide credit to the masses. Banks were required to hold large percentages of their portfolios in government securities bought at concessional interest rates. In 1977, the government began requiring any bank which wanted to open a branch in an area which already had a bank branch to open four branches in rural areas with no financial services (Burgess and Pande, 2005).

Liberalization in the banking sector was handled by the Reserve Bank of India with a focus on maintaining viability of existing banks while increasing competition and efficiency in the sector (Reddy, 2005). In 1994, liberalization began with increased approval of the private banks. In 2001, the government began deregulation of interest rates and in 2002 foreign participation in the banking sector was allowed up to 49 percent in private banks. Competitiveness of the national banks was increased through mergers, voluntary retirement schemes and the creation of asset management
companies to deal with non-performing assets. In 2004, foreign banks were allowed to own up to 74 percent stake in branches listed by the reserve Bank of India as having weak portfolios. Currently, foreign banks may now operate through licensed branches and as fully owned subsidiaries (Arnold et al., 2008).

4.2.4 Insurance

Prior to liberalization, the insurance sector was controlled by the Ministry of Finance through publicly owned companies. In 1999, the Insurance Regulatory Development Authority bill was passed which allowed private companies to enter the insurance market. Foreign sector participation is restricted to 26 percent currently and foreign firms are allowed to enter only through partnerships or joint ventures. Entry into the insurance market by the private sector providers finally began in 2002 when the twelve private sector insurers entered the market (Arnold et al., 2008).

4.2.5 Air transport

Prior to liberalization, all subsectors of transport services were operated primarily by public sector companies. Air transport was run by two publicly owned carriers, states controlled the ports for maritime industries and a large segment of the shipping industry was heavily regulated by publicly owned companies. In 1997, foreign direct investment up to 40 percent was allowed in airlines, 74 percent foreign direct investment was allowed in port construction. The railways is still controlled by the Ministry of Railways and is closed to private sector participation (Arnold et al., 2008).
4.2.6 Other services

Professional services including accounting legal and other services such as retail distribution, postal services etc. are formally closed to foreign participation.

4.3 Labor market regulation

Under the Indian Constitution of 1950, industrial regulations is a concurrent subject. Thus the central and state governments have joint jurisdiction over labor regulation legislation. The key piece of central legislation is the Industrial Dispute Act of 1947 which sets out the conciliation, arbitration and adjudication procedures to be followed in the case of industrial dispute. The Act was designed to offer workers in the organized sector some protection against exploitation by employers. This Act has been extensively amended by the state governments in the post-independence years.

The coding of amendments have been constructed by Besley and Burgess (2004) for the 1958-1992 period. The coding is based on reading all state level amendments to the Industrial Dispute Act of 1947 from Malik (1997). Although all states have the same starting point, they diverged from one another over time. Each amendment is coded as being either neutral, pro-worker or pro-employer. For the purpose of empirical estimations, I have coded each pro-worker amendment as 1, each neutral amendment as 0 and each pro-employer amendment as -1. If there were multiple amendments in a given year, then all the amendments are added to give the net direction of change.

For my purpose, I consider the labor regulation index of the Indian states post
1991. The Industrial Dispute Act has not been amended since 1989 and hence I follow the code constructed by Besley and Burgess (2004). The following table charts out the different states in India based on their labor regulation index since 1989.

<table>
<thead>
<tr>
<th>State</th>
<th>Labor regulation category since 1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>Pro-employer</td>
</tr>
<tr>
<td>Assam</td>
<td>Neutral</td>
</tr>
<tr>
<td>Bihar</td>
<td>Neutral</td>
</tr>
<tr>
<td>Gujarat</td>
<td>Pro-worker</td>
</tr>
<tr>
<td>Haryana</td>
<td>Neutral</td>
</tr>
<tr>
<td>Jammu &amp; Kashmir</td>
<td>Neutral</td>
</tr>
<tr>
<td>Karnataka</td>
<td>Pro-employer</td>
</tr>
<tr>
<td>Kerala</td>
<td>Pro-employer</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>Neutral</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>Pro-worker</td>
</tr>
<tr>
<td>Orissa</td>
<td>Pro-worker</td>
</tr>
<tr>
<td>Punjab</td>
<td>Neutral</td>
</tr>
<tr>
<td>Rajasthan</td>
<td>Pro-worker</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>Pro-worker</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>Neutral</td>
</tr>
<tr>
<td>West Bengal</td>
<td>Pro-worker</td>
</tr>
</tbody>
</table>

The Besley and Burgess (2004) index has been in wide use since it captures the salient features of labor regulations in India. Using this index, Besley and Burgess
(2004) have shown evidence that more pro-worker labor regulation is strongly positively correlated with measures of industrial disputes such as work-days lost through worker strikes and lock-outs for the pre-1992 period. Sanyal and Menon (2005) demonstrate that new industrial plants in India tend to open more in pro-employer states which suffer from less industrial disputes. Aghion et al. (2008) conclude that manufacturing firms located in the pro-employer states in India have more incentive to invest in innovations and compete with new firms.

Some shortcomings of the Besley and Burgess labor index have been pointed out by Bhattacharjrea (2006) on the grounds that there is a gap between the actual law enacted and the degree of enforcement of these laws. Nevertheless, this labor index is a convenient and widely-used tool to track the varying labor regulations across states in India.

4.4 Theoretical model

Reforms in the service sector have primarily dismantled public sector dominance by allowing large-scale private sector participation along with participation of foreign firms. Increased competition has led to improved technological adoption across the reformed sectors although weak firms have perished due to the same reason. In this section I present a theoretical model taken from Aghion and Burgess (2003) that outlines firm behavior and performance in the wake of a possible entry of new firms.
4.4.1 Multi-sector Schumpeterian growth model

Final good $y_t$ is produced by a competitive sector using a continuum of intermediate inputs according to the technology:

$$y_t = \frac{1}{\alpha} \left[ \int_0^1 (A_t(v))^{1-\alpha} x_t(v)^\alpha \, dv \right],$$

where: $x_t(v)$ is the quantity of intermediate input produced in sector $v$ at date $t$, $A_t(v)$ is the productivity parameter that measures the quality of the intermediate input $v$ in producing the final good, and $\alpha \in (0, 1)$. The final good is used as an input in the process of production of intermediate goods.

In equilibrium:

$$p_t(v) = (A_t(v))^{1-\alpha} x_t(v)^{\alpha-1}. \tag{1}$$

In each intermediate sector $v$ only one firm (monopolist) is active in each period. The monopolist maximizes profit:

$$\max \Pi_t(v) = p_t(v)x_t(v) - x_t(v).$$

Inserting the expression for $p_t(v)$ from equation (1) in the above profit maximization problem, the first-order condition yields:

$$p_t(v) = \frac{1}{\alpha}. \tag{2}$$

Substituting for the expression for $p_t(v)$ from equation (2) in equation (1), and
solving for $x_t(v)$ gives:

$$x_t(v) = A_t(v)\alpha^{\frac{1}{1-\alpha}}. \quad (3)$$

The profit function of the monopolist is now given by:

$$\Pi_t(v) = \delta A_t(v) \text{ where } \delta \equiv \left(\frac{1 - \alpha}{\alpha}\right)\alpha^{\frac{1}{1-\alpha}}. \quad (4)$$

Aghion et al. (2008) interpret $\delta$ as the bargaining power of the firm vis-a-vis its workers, with a higher $\delta$ corresponding to a more pro-employer labor market environment.

4.4.2 Technology and entry

Following Aghion and Burgess (2003), let $\overline{A}_t$ denote the new frontier productivity at date $t$ and this frontier grows at an exogenous rate $g$. At any given date $t$ an intermediate firm can be either close to this frontier with productivity level $A_{t-1}(v) = \overline{A}_{t-1}$, or far below the frontier with productivity level $A_{t-1}(v) = \overline{A}_{t-2}$.

Before the firms produce and generate profits, firms can innovate to increase their productivity. For innovation to be successful with probability $z$ the intermediate firm at date $t$ must invest

$$c_t(z) = \frac{1}{2}z^2A_{t-1}(v). \quad (5)$$

Intermediate firms face potential entry threat from new firms. Let $\mu$ be the probability that an entrant shows up. Liberalization is modeled as an increase in $\mu$. New entrants are assumed to operate with the end-of-period frontier productivity $\overline{A}_t$.

If a new firm manages to enter, it faces one of the two types of incumbents. If the
incumbent firm is operating far below the productivity frontier, then the new entrant captures the market and the incumbent ceases to exist. If the new entrant competes with an existing firm that has the same productivity, then Bertrand competition drives profits to zero for both the entrant and the incumbent firms. We assume the parameters to be such that the new firm will always find it profitable to enter if the local firm has a productivity level lower than the frontier. The new firm will never enter in period $t$ if the local firm is already operating at the frontier productivity level $\bar{A}_t$. Thus, if an existing “advanced” firm that has already innovated and reached the frontier level of productivity, the probability of actual entry of new firms is zero.

4.4.3 Equilibrium innovation investments

Combining the potential entry threat of new firms with the profit function obtained in equation (4) and the innovation cost in equation (5), we analyze the innovation decisions by the intermediate firms that are close and far below the frontier. Firms that are initially far below the frontier at date $t$ choose their investment so as to maximize expected profits net of innovation costs:

$$\max_z \left\{ \delta \left[ z(1 - \mu)\bar{A}_{t-1} + (1 - z)(1 - \mu)\bar{A}_{t-2} \right] - \frac{1}{2} z^2 \bar{A}_{t-2} \right\},$$

so that by first-order condition:

$$z_2 = \delta(1 - \mu)g.$$  \hfill (6)
Firms that are initially close to the frontier choose their investment decision so as to:

$$\max_z \left\{ \delta [z\bar{A}_t + (1 - z)(1 - \mu)\bar{A}_{t-1}] - \frac{1}{2}z^2\bar{A}_{t-1} \right\},$$

so that:

$$z_1 = \delta(g + \mu). \quad (7)$$

Note in the above profit maximization problems, the terms \((1 - z)\mu\bar{A}_{t-2}\) and \((1 - z)\mu\bar{A}_{t-1}\) are omitted from the right hand side. According to our assumption, if firms fail to innovate and continue to operate below the frontier, then new firms take over the entire market share since they operate at the frontier productivity levels. Thus both \((1 - z)\mu\bar{A}_{t-2}\) and \((1 - z)\mu\bar{A}_{t-1}\) are equal to zero and do not feature in the above profit maximizing equations. Also note that new firms will not enter if \(A_{t-1}\) innovates to \(A_t\).

Liberalization reforms is interpreted as an increase in entry threat \(\mu\). Differentiation of the equilibrium innovation intensities in equations (7) and (6) with respect to \(\mu\) yields:

$$\frac{\partial z_1}{\partial \mu} = \delta > 0; \quad \frac{\partial z_2}{\partial \mu} = -\delta g < 0.$$

Thus, increasing the threat of product entry encourages innovation in advanced firms and discourages it in backward firms. Existing firms closer to the productivity frontier have incentives to innovate in the wake of entry threat of new firms. Firms far below the frontier have no chance to win over the potential entrants and hence they do not innovate.
The effects of changes in labor market regulations on innovative investments are as follows:

\[
\frac{\partial z_1}{\partial \delta} = (g + \mu) > 0; \frac{\partial z_2}{\partial \delta} = (1 - \mu)g > 0.
\]

Thus, pro-employer labor market regulations encourage innovation across all types of firms.

Lastly, the cross-partial derivatives with respect to reform (\(\mu\)) and labor regulation (\(\delta\)) are:

\[
\frac{\partial^2 z_1}{\partial \delta \partial \mu} = 1 > 0; \frac{\partial^2 z_2}{\partial \delta \partial \mu} = -g < 0.
\]

Thus, a more pro-employer labor regulation increases the positive impact of entry on innovation investments in frontier industries.

### 4.4.4 Main theoretical predictions

The above model by Aghion et al. (2003) predicts the following:

1. **Liberalization (as measured by an increase in the threat of entry)** encourages innovation in firms which are close to the frontier and discourages innovation in firms that are far from it. Productivity, output and profits, should thus be higher in firms that are initially more advanced.

2. **Pro-worker labor market regulations** discourage innovation and growth in all industries and the negative effect increases with liberalization.
4.5 Empirical analysis

4.5.1 Model 1

To test the prediction about overall firm performance and firm entry, the following panel regression is estimated:

\[ y_{it} = \alpha_i + \beta_t + \gamma_{jt}t + \theta_s + \eta x_{jt} + u_{it}, \]  

(8)

where \( i \) indexes a firm/company, \( j \) indexes the service industry to which the firm belongs, \( s \) denotes the location (Indian state) of the firm’s headquarters and \( t \) denotes years.

\( y_{it} \) denotes the \( i^{th} \) service-firm’s performance (measured as output, profits or productivity) in time period \( t \).

\( \alpha_i \) captures firm fixed effects. These factors like managerial capabilities, ownership etc. controls for unobserved heterogeneity across firms.

\( \beta_t \) is the year dummy which controls for common macroeconomic shocks.

\( \gamma_{jt}t \) controls for industry time trend where \( j \) stands for industry.

\( \theta_s \) controls for location time trend where each firm \( i \) belongs to a unique state represented by \( s \).

\( x_{jt} \) indicates the service policy reform index for industry \( j \) in year \( t \). This time-varying index has been constructed by Arnold, Javorcik, Lipscomb and Mattoo (2008) for 4 industries in India from 1992-2005. They are telecommunications, transport, banking and insurance industries. Following their reform specifications, I construct a
similar index for the computer industry. The industry-specific index takes on a value between 0 and 5 depending upon the waves of reforms within an industry. Figure 4.2 presents a graphical representation of services policy reform index (Arnold et al., 2008). The aggregate service policy reform index is a weighted average of these industry-specific indices. Since increments in the reform index is primarily based on the degree of entry of private firms and foreign firms, $x_{jt}$ corresponds to the probability of entry measure $\mu$ in the theoretical model.

In an alternate specification, $x_{jt}$ is a 0/1 dummy which switches on when an industry allows participation of private firms. In either case, a positive value of $\eta$ indicates the overall positive impact of liberalization or firm-entry on firm performance.

Source: Arnold et al., 2008, author’s own calculations.

Figure 4.2. Services policy reform index
4.5.2 Model 2a

A second panel equation is estimated to capture the effects of liberalization or firm entry on firm performance based on firm type\(^1\).

\[
y_{it}^* = \alpha_i^* + \beta_t^* + \gamma_j^* t + \theta_s^* t + \delta_1(x_{jt})(d_{it}) + \delta_2(x_{jt})(1 - d_{it}) + \zeta(s_t)(x_{jt}) + u_{it}^*, \tag{9}
\]

where \(y_{it}^*\) denotes the service-firm’s performance outcome (output, profit, productivity etc.) in logs. \(\alpha_i^*, \beta_t^*, \gamma_j^*, \theta_s^*\) and \(u_{it}^*\) are equivalent to \(\alpha_i, \beta_t, \gamma_j, \theta_s\) and \(u_{it}\) in equation (8).

As in equation (8), \(x_{it}\) is a 0/1 dummy which switches on when an industry allows participation of private firms.

\(d_{it}\) is a dummy variable for distance to the productivity frontier defined as productivity of firm \(i\) within industry \(j\) in year \(t\), divided by the maximum productivity in industry \(j\) in year \(t\). This is obtained from the ratio of the Solow residual estimated for each firm. This measure equals 1 for firms closer to the frontier \((A_{it}/A_{jt(max)} \geq 0.5)\) and 0 for non-frontier firms \((A_{it}/A_{jt(max)} < 0.5)\).

\(\delta_1\) and \(\delta_2\) are the coefficients of interaction dummy. A positive value of \(\delta_1\) indicates that firms which were closer to the frontier in the pre-entry phase performed better in the post-entry era. One would expect a negative value of \(\delta_2\) indicating firms which were further from the frontier in the pre-entry period performed worse in the post-entry years.

\(^1\)It is possible that liberalization or firm entry depends on a sector’s performance or potential performances. For example, firm entry may be most likely in sectors with high growth potential. The issue of endogeneity cannot be ruled out completely. However, no satisfactory instrument could be found.
The above equation is also used to link labor regulation status of states with liberalization and firm performance. \( l_s \) is the Besley and Burgess labor index for each state in India since 1992. \( l_s \) takes a value \(-1\) if the firm is located in a state which is pro-employer, it is 0 if the state is classified as neutral and takes a value 1 if it is a pro-worker state. Since the Industrial Dispute Act of 1947, based on which this index has been constructed, has not been amended since 1989, \( l_s \) is hence a time invariant index in this analysis.

\( \zeta \) is the coefficient of the interaction between labor regulation and liberalization in the particular industry \( j \) to which firm \( i \) belongs. A positive value of \( \zeta \) implies firms located in pro-worker states have performed better in the post-liberalization phase. If \( \zeta \) is negative, then firms located in the pre-employer states have performed better after liberalization.

### 4.5.3 Model 2b

A third panel equation is estimated which is a variant of Model 2a. This estimation is similar to the model estimated in equation (9).

\[
y_{it}^* = \alpha_i^* + \beta_t^* + \gamma_j^* t + \theta_s^* t + \delta_1 r_{it} + \delta_2 (x_{jt})(r_{it}) + \zeta (l_s)(x_{jt}) + u_{it}, \tag{10}
\]

where all variables are same as those in equation (9). Instead of using a dummy variable to classify frontier and non-frontier firms, we use the variable \( r_{it} \) which is the firm’s distance to the frontier. This is given by the term \((1 - A_{it}/A_{jt(\text{max})})\). If the theoretical prediction holds true, then we would expect \( \delta_1 \) to be negative. In other
words, if distance to the frontier is less, then firms benefit from liberalization.

4.6 Data

Company-level data for the Indian service sector have been obtained from the *Prowess* database provided by the Center for Monitoring Indian Economy (CMIE). The *Prowess* database contains detailed characteristics of all publicly listed companies in India.

I use the annual data for the service sector companies based on their Standard Industrial Classification (SIC) codes, from 1991 through 2005. The data include: gross income, profit after tax, gross fixed assets, capital expenses, labor compensation and the location of the company headquarters.

Data on gross income include income from sales, income from financial services and other income.

Compensation to employees include payments made in cash or kind by a company to its workers. It includes salaries, bonus, contribution towards provident funds, staff training expenses, arrears, reimbursements etc. Company employment figures are very spotty, hence compensation to employees is used as a proxy for employment. In a crude sense, labor compensation variable also controls for labor quality.

Capital data is obtained from book value of gross fixed assets of each company.

The “services policy reform index” (SPRI) used for estimation is from Arnold et al. (2008). The detailed construction of the index is outlined in the *Appendix* section of this paper. Following their specifications, I calculate a similar index for the
IT industry.

The labor regulation index is based on Besley and Burgess (2004). Detailed description of the index was presented in Section (4.3).

Out of several industries, I consider five major service industries where significant economic reforms have taken place. These are: banking, business services (IT), insurance, telecommunications and transportation.

4.7 Results

The key results from estimating equation (8) are shown in Table 4.1. Two different specifications of equation (8) are used to model service liberalization in the Indian context. In the first specification, the “services policy reform index” is used as a measure of service liberalization. In the second specification, a 0/1 dummy for entry of private firms in the service industries represents liberalization.
<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log(Output)</td>
<td>Log(Productivity)</td>
<td>Log(Profit)</td>
</tr>
<tr>
<td><strong>Specification 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liberalization index</td>
<td>0.059**</td>
<td>0.077**</td>
<td>0.084***</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
<td>(0.036)</td>
<td>(0.055)</td>
</tr>
<tr>
<td><strong>Specification 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm entry</td>
<td>0.064**</td>
<td>0.063**</td>
<td>0.069***</td>
</tr>
<tr>
<td></td>
<td>(0.039)</td>
<td>(0.030)</td>
<td>(0.045)</td>
</tr>
<tr>
<td><strong>Both specifications</strong></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Balanced panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>75543</td>
<td>75543</td>
<td>75543</td>
</tr>
</tbody>
</table>

*, **, ***: Significant at 1%, 5% and 10% levels respectively

Table 4.1. Liberalization and service firm performance in India: 1991-2005

For both measures of liberalization we see that in general, reforms have had a positive impact on firm output, net-of-tax profit and productivity.
However, equation (8) does not segregate firm performance based on the firm type. Table 4.2 and 4.3 present the main results of equation (9) where firms are distinguished based on their proximity to the technology frontier. In Table 4.2, the service reform index by Arnold et al. (2008) measures liberalization while in Table 4.3, firm entry is considered as a proxy for liberalization. Except for the measure of service sector liberalization, both tables are based on the same set of variables and data used in estimating equation (9).
Columns (1), (2) and (3) in Table 4.2 and Table 4.3 indicate that effects of service sector reforms have had varied by firm type. Firms which were closer to the frontier in the pre-reform years have higher output on average in the post-reform phase. In contrast the effects for the output of firms which were far from the frontier before

<table>
<thead>
<tr>
<th>Period: 1991-2005</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log(Output)</td>
<td>Log(Productivity)</td>
<td>Log(Profit)</td>
</tr>
<tr>
<td>Liberalization × Frontier firms</td>
<td>0.291* (0.037)</td>
<td>0.182* (0.025)</td>
<td>0.206* (0.050)</td>
</tr>
<tr>
<td>Liberalization × Non-frontier firms</td>
<td>0.012 (0.036)</td>
<td>-0.137 (0.024)</td>
<td>0.054 (0.048)</td>
</tr>
<tr>
<td>Labor regulation × Liberalization</td>
<td>-0.008 (0.011)</td>
<td>0.019** (0.008)</td>
<td>-0.010 (0.018)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
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</tr>
<tr>
<td>State time trends</td>
<td>Yes</td>
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<td>Yes</td>
</tr>
<tr>
<td>Balanced panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>75543</td>
<td>75543</td>
<td>75543</td>
</tr>
</tbody>
</table>

* *, **, ***: Significant at 1%, 5% and 10% levels respectively

Table 4.2. Effect of liberalization on performance by firm type in India: Model 2a
reforms is small and statistically insignificant.

As predicted by the theoretical model in section 4.4, post-reforms productivity is higher for all those firms which were closer to the technology frontier before reforms. On the contrary, pre-reform non-frontier firms registered a drop in productivity levels after reforms. These results bore well with the theoretical predictions. Pre-reform frontier firms have better incentives to innovate to stay in business and compete with new entrants. Entry of new firms is a natural fallout of liberalization. If firms were lying far below the frontier initially, then they do not innovate since their chances of survival in the wake of new entrants who come with frontier technology, is almost nil.
Table 4.3. Effect of firm entry on performance by firm type in India: Model 2a

<table>
<thead>
<tr>
<th></th>
<th>Log(Output)</th>
<th>Log(Productivity)</th>
<th>Log(Profit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm entry × Frontier firms</td>
<td>0.296*</td>
<td>0.180*</td>
<td>0.216*</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.026)</td>
<td>(0.052)</td>
</tr>
<tr>
<td>Firm entry × Non-frontier firms</td>
<td>0.018</td>
<td>-0.138*</td>
<td>0.065</td>
</tr>
<tr>
<td></td>
<td>(0.037)</td>
<td>(0.025)</td>
<td>(0.050)</td>
</tr>
<tr>
<td>Labor regulation × Firm entry</td>
<td>-0.021</td>
<td>0.017</td>
<td>-0.035</td>
</tr>
<tr>
<td></td>
<td>(0.024)</td>
<td>(0.016)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Balanced panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>75543</td>
<td>75543</td>
<td>75543</td>
</tr>
</tbody>
</table>

*, **, ***: Significant at 1%, 5% and 10% levels respectively

As a result of innovative investments they make, one would expect profits to be greater post liberalization in firms in advanced firms relative to the backward firms. Column (3) of both tables 4.2 and 4.3 confirms that this is the case. It is the lure of these greater profits that leads firms to invest in new procedures and technologies.
whereas exactly the opposite is true for technologically backward firms which stand little chance of competing in the post-liberalization period.

The above results are reinforced when we estimate equation (10). It is evident from Tables 4.4 and 4.5 that irrespective of the measure of liberalization that we use, firms which were closer to the frontier in the pre-reform era, benefitted from liberalization. A negative coefficient in the third row of the tables confirm this. Note that we are using each firm’s distance to the frontier. The lower this distance, it implies that the firms are closer to the technological frontier. The second row in both the tables confirm that lesser the distance between the firms and the technological frontier, better is the firm performance. Reforms; measured by the liberalization index and also by firm entry, have had a positive impact on the performance of the
firms and thus the coefficients are all positive in the first row of both the tables.

<table>
<thead>
<tr>
<th>Period: 1991-2005</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log(Output)</td>
<td>Log(Productivity)</td>
<td>Log(Profit)</td>
</tr>
<tr>
<td>Liberalization Index</td>
<td>0.238*</td>
<td>0.122*</td>
<td>0.013*</td>
</tr>
<tr>
<td></td>
<td>(0.019)</td>
<td>(0.011)</td>
<td>(0.032)</td>
</tr>
<tr>
<td>Distance to frontier</td>
<td>-1.811*</td>
<td>-1.533*</td>
<td>-1.224*</td>
</tr>
<tr>
<td></td>
<td>(0.161)</td>
<td>(0.093)</td>
<td>(0.258)</td>
</tr>
<tr>
<td>Liberalization × Distance to frontier</td>
<td>-0.212*</td>
<td>-0.240*</td>
<td>-0.145*</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.009)</td>
<td>(0.024)</td>
</tr>
<tr>
<td>Labor regulation × Liberalization</td>
<td>-0.006</td>
<td>0.021*</td>
<td>-0.008</td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.006)</td>
<td>(0.018)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Balanced panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>75543</td>
<td>75543</td>
<td>75543</td>
</tr>
</tbody>
</table>

*, **, ***: Significant at 1%, 5% and 10% levels respectively

Table 4.4. Effect of liberalization on performance by firm type in India: Model 2b
### Table 4.5. Effect of firm entry on performance by firm type in India: Model 2b

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log(Output)</td>
<td>Log(Productivity)</td>
<td>Log(Profit)</td>
</tr>
<tr>
<td>Firm entry</td>
<td>0.559*</td>
<td>0.571*</td>
<td>0.426*</td>
</tr>
<tr>
<td></td>
<td>(0.061)</td>
<td>(0.036)</td>
<td>(0.095)</td>
</tr>
<tr>
<td>Distance to frontier</td>
<td>-1.863*</td>
<td>-1.158*</td>
<td>-1.248*</td>
</tr>
<tr>
<td></td>
<td>(0.230)</td>
<td>(0.135)</td>
<td>(0.363)</td>
</tr>
<tr>
<td>Firm entry × Distance to frontier</td>
<td>-0.607*</td>
<td>-0.817*</td>
<td>-0.411*</td>
</tr>
<tr>
<td></td>
<td>(0.066)</td>
<td>(0.039)</td>
<td>(0.104)</td>
</tr>
<tr>
<td>Labor regulation × Firm entry</td>
<td>-0.004</td>
<td>0.031**</td>
<td>-0.023</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.013)</td>
<td>(0.035)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State time trends</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Balanced panel</td>
<td>No</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Observations</td>
<td>75543</td>
<td>75543</td>
<td>75543</td>
</tr>
</tbody>
</table>

* *, **, ***: Significant at 1%, 5% and 10% levels respectively

Thus the overall impact of service liberalization in India is mixed. While technologically advanced firms gained more after reforms, their technologically challenged
counterpart could not take advantage of liberalization.

No strong evidence between labor regulation and reforms can be drawn from the given sample. For all indicators of firm performance—output, productivity and profit, the coefficients are statistically insignificant. The only exception is productivity which is higher during the post-reform era in the pro-labor states when liberalization is measured using the reform index of Arnold et al. (2008). While for the manufacturing sector, Aghion et al. (2008) showed that pro-employer firms have performed better in the post-reform period, no such conclusion can be drawn for the service sector. This might have to do with the data being used in this analysis. We have data on the location of the company headquarters but not on the location of the individual plants. If data on service sector plants become available, then one see a clearer relation between state-specific labor regulation and impact of liberalization.

4.8 Conclusion

The service sector-led growth in India in recent years is an area of ongoing empirical research. This paper follows the methodology by Aghion and others (2003, 2008) to assess the impact of liberalization on service sector firms in India between 1992 and 2005. Liberalization is modelled in two ways in this paper. In one specification, entry of private firms is taken as a proxy for liberalization. In another case, the “service policy reform index” - a time varying index capturing the various phases of reforms, is another measure of liberalization. I find that firms which were initially closer to the technological frontier in the pre-reform stage, have better economic performance and
higher productivity levels in the post-reform years primarily due to rapid technolog-
cal adoption introduced by new entrants. On the contrary, firms which were far below
the technology frontier before the reforms, registered low productivity levels after lib-
eralization in the service sector. No strong linkage between labor regulation and its
impact on service liberalization is found. Thus there is evidence of Schumpeterian
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Appendix: Background Calculations for Transition Accounting

A.1 Input Prices

Assuming interiority, the first-order conditions for intermediate goods producers are

\begin{align}
(1 - \mu) \frac{p_m Y_m}{L_m} & = w_m, \quad (1a) \\
(1 - \sigma) \frac{p_s Y_s}{L_s} & = w_s, \quad (1b) \\
(1 - \alpha) \frac{p_a Y_a}{L_a} & = w_a, \quad (1c) \\
\alpha \frac{p_a Y_a}{K_a} & = \mu \frac{p_m Y_m}{K_m} (1 + \kappa_m) = \sigma \frac{p_s Y_s}{K_s} (1 + \kappa_s). \quad (1d)
\end{align}

Under perfect competition and constant returns, the average cost of the final good will equal its price, and it follows from equations (3a) to (3c) that

\begin{align}
p & = \frac{1}{V} \left[ p_a Y_a + p_m Y_m + p_s Y_s \right] \\
& = \frac{1}{V} \left[ p\psi Y + p\eta Y + p\theta Y \right] = 1. \quad (2)
\end{align}

Combining these results with equations (3a) to (3c) produces equations (4a)-(5c).
A.2 Input Aggregation

Combining equations (1a)-(2), and inserting equations (5a)-(5c) produces

\[ K_a = \frac{\alpha \psi}{\zeta(1 + \kappa)} K, \]  
\[ K_m = \frac{\eta \mu (1 + \kappa_m)}{\zeta(1 + \kappa)} K, \]  
\[ K_s = \frac{\theta \sigma (1 + \kappa_s)}{\zeta(1 + \kappa)} K, \]  
\[ \kappa \equiv \frac{1}{\zeta} [\eta \mu \kappa_m + \theta \sigma \kappa_s], \]  
\[ \zeta \equiv \alpha \psi + \eta \mu + \theta \sigma. \]

and we can rewrite equation (2) as:

\[ Y = \hat{A} \Omega K^\xi L_a^{\psi(1-\alpha)} L_m^{\eta(1-\mu)} L_s^{\theta(1-\sigma)}, \]  
where

\[ \hat{A} \equiv A_f A_\psi A_\eta A_\theta \zeta^{-\xi} (\alpha \psi)^{\alpha \psi} (\eta \mu)^{\eta \mu} (\theta \sigma)^{\theta \sigma}, \]  
\[ \Omega \equiv \frac{(1 + \kappa_m)^{\eta \mu} (1 + \kappa_s)^{\theta \sigma}}{(1 + \kappa)^{\zeta}}. \]

Combining equations (4a) to (4c) with equation (7) produces

\[ \psi(1 - \alpha) \frac{Y}{L_a} = \eta(1 - \mu) \frac{Y}{L_m} (1 + \ell_m) = \theta(1 - \sigma) \frac{Y}{L_s} (1 + \ell_s). \]
Letting $\ell$ denote the average labor market “distortion”,

$$\ell = \frac{1}{1 - \zeta} \left[ \eta(1 - \mu)\ell_m + \theta(1 - \sigma)\ell_s \right],$$

we can rewrite the preceding equations as

$$L_a = \frac{\psi(1 - \alpha)}{(1 - \zeta)(1 + \ell)} L,$$

$$L_m = \frac{\eta(1 - \mu)(1 + \ell_m)}{(1 - \zeta)(1 + \ell)} L,$$

$$L_s = \frac{\theta(1 - \sigma)(1 + \ell_s)}{(1 - \zeta)(1 + \ell)} L.$$

Inserting these results into equation (27) and rearranging to find equation (8):

$$Y = A^{1-\zeta} K^\zeta L^{1-\zeta},$$

with the term $A$ defined as in the main text.

Combining equations (4a), (7) and (28), we can rewrite the labor-leisure allocation condition as

$$\chi \frac{CL^\gamma}{N^{1+\gamma}} = \psi(1 - \alpha) \frac{Y}{L_a} = (1 - \zeta)(1 + \ell)(1 - \tau_i) \frac{Y}{L}.$$

This is equation (9) in the main text.
Combining equations (3a) and (26) produces

\[ \zeta (1 + \kappa) \frac{Y}{K} = r. \]  \hspace{1cm} (6)

Combining equations (6) and (29) produces equation (11) in the main text.

A.3 Normalized Production

Let lower case variables denote upper case variables divided by population and

\[ c_t = C_t / (A_t N_t), \] and so on. The one exception is labor

\[ l_t = L_t / N_t. \] Inserting these definitions into equations (8) and (9), we

get equation (15) in the main text:

\[
y_t = k_t^{\zeta_t} (a_t l_t)^{1 - \zeta_t},
\]

\[
= \frac{\chi c_t l_t^{1 + \gamma}}{(1 - \zeta_t)(1 + \ell_t)(1 - \tau_t)},
\]

\[
= \left( k_t^{\zeta_t} a_t^{1 - \zeta_t} \right) \phi_t c_t^{1 - \phi_t} \left( \frac{1}{\chi} (1 - \zeta_t)(1 + \ell_t)(1 - \tau_t) \right)^{-\phi_t - 1},
\]

with \( a_t \) and \( \phi_t \) defined as in the main text.

A.4 Linearization

Let hats ("\^") denote deviations around the transition path. The tax rates, the

allocation wedges (the \( \kappa \)'s and the \( \ell \)'s), the production parameters (\( \zeta \) and \( \phi \)), and the

depreciation rate (\( \delta \)) are expressed as level deviations; in these cases \( \hat{x}_t = x_t - x_t^* \). All

other variables are expressed as log deviations; in these cases, \( \hat{x}_t = \ln (x_t / x_t^*) \).
Consider the Euler equation

\[
\frac{1}{c_t} = \beta \frac{N_{t+1}}{N_t} E_t \left( \frac{1}{c_{t+1}} (G^*_{t+1})^{-1} \left[ 1 + \zeta_{t+1} (1 + \kappa_{t+1}) \frac{y_{t+1}}{\kappa_{t+1}} - \delta_{t+1} \right] \right) \frac{1}{1 + \tau_{kt}};
\]

We can rewrite this expression as

\[
\frac{1}{c_t} \exp (-\hat{c}_t) = \frac{1}{1 + \tau^*_{kt} + \hat{\tau}_{kt}} \times \beta E_t \left( \frac{1}{c_{t+1}} \exp (-\hat{c}_{t+1}) (G^*_{A,t+1})^{-1} \times \right.
\]

\[
\left. \left[ 1 + (\zeta^*_{t+1} + \hat{\zeta}_{t+1})(1 + \kappa^*_{t+1} + \hat{\kappa}_{t+1}) \frac{y^*_{t+1}}{\kappa^*_{t+1}} \exp \left( \hat{y}_{t+1} - \hat{\kappa}_{t+1} \right) - \left( \delta^*_{t+1} + \hat{\delta}_{t+1} \right) \right] \right),
\]

where \( G^*_{A,t+1} = A^*_{t+1}/A^*_t \). Logging both sides, and assuming the deviations are small, one gets

\[
-\hat{c}_t \approx \ln \left( \lambda_{2,t+1} \right) - \ln (1 + \tau^*_{kt} + \hat{\tau}_{kt}) - E_t \left\{ \hat{c}_{t+1} \right\}
\]

\[
+ E_t \left\{ \ln \left( 1 + (\zeta^*_{t+1} + \hat{\zeta}_{t+1})(1 + \kappa^*_{t+1} + \hat{\kappa}_{t+1}) \lambda_{1,t+1} \exp \left( \hat{y}_{t+1} - \hat{\kappa}_{t+1} \right) - \left( \delta^*_{t+1} + \hat{\delta}_{t+1} \right) \right) \right\},
\]

\[
\lambda_{1t} \equiv \frac{y^*_{t}}{\kappa^*_{t}}; \quad \lambda_{2t} \equiv \beta \frac{c^*_{t-1}}{c^*_t} (G^*_{A,t})^{-1}.
\]

Implicitly differentiating around trend values (“stars”, with “hats” set equal to zero), and noting that

\[
1/ \left[ 1 + \zeta_{t+1} (1 + \kappa^*_{t+1}) \lambda_{1,t+1} - \delta_{t+1} \right] = \lambda_{2,t+1}/(1 + \tau^*_{kt}),
\]

we get

\[
-\hat{c}_t \approx E_t \left( \hat{c}_{t+1} - \lambda_{3,t+1} \left( \frac{1}{\kappa^*_{t+1}} \hat{\zeta}_{t+1} + \hat{y}_{t+1} - \hat{\kappa}_{t+1} + \frac{1}{1 + \kappa^*_{t+1}} \hat{\kappa}_{t+1} \right) - \lambda_{2,t+1} \frac{\hat{\delta}_{t+1}}{1 + \tau^*_{kt}} \right) + \frac{1}{1 + \tau^*_{kt}} \hat{\tau}_{kt},
\]

\[
\lambda_{3t} \equiv \frac{\zeta^*_{t+1} \lambda_{1,t+1} \lambda_{2,t+1} (1 + \kappa^*_{t+1})}{1 + \tau^*_{kt}}.
\]

Following equation (23), we replace \( \hat{\tau}_{kt} \) with \( \rho_k \hat{\tau}_{k,t-1} \).
Next, consider the capital accumulation equation

\[ G_{t+1}^* k_{t+1} = (1 - \delta_t) k_t + y_t - c_t - g_t, \]

which can be rewritten as

\[ G_{t+1}^* k_{t+1} \exp \left( \hat{k}_{t+1} \right) = \left( 1 - \left( \delta_t^* + \hat{\delta}_t \right) \right) k_t^* \exp \left( \hat{k}_t \right) + y_t^* \exp \left( \hat{y}_t \right) = -c_t^* \exp (\hat{c}_t) - g_t^* \exp (\hat{g}_t). \]

Implicit differentiation yields

\[ G_{t+1}^* k_{t+1} \hat{k}_{t+1} = k_t^* \left( 1 - \delta_t^* \right) \hat{k}_t - k_t^* \hat{\delta}_t + y_t^* \hat{y}_t - c_t^* \hat{c}_t - g_t^* \hat{g}_t, \]

or

\[ \lambda_{4,t+1} \hat{k}_{t+1} = (1 - \delta_t^*) \hat{k}_t + \lambda_{1t} \hat{y}_t - \lambda_{5t} \hat{c}_t - \lambda_{6t} \hat{g}_t - \hat{\delta}_t, \]

\[ \lambda_{4t} = \frac{k_t^*}{k_{t+1}^*} G_t^*; \quad \lambda_{5t} = \frac{c_t^*}{k_t^*}; \quad \lambda_{6t} = \frac{g_t^*}{k_t^*}. \]

To fill out these two difference equations, we substitute for output, using

\[ y_t = \left( \frac{1}{\lambda} \left( 1 - \zeta_t \right) \left( 1 - \tau \right) (1 + \ell_t) \right)^{\phi_t^{-1}} \left( k_t^* a_t^{1-\zeta_t} \right)^{\phi_t} c_t^{1-\phi_t}. \quad (7) \]

Linearizing this equation requires us to consider the effects of the exponent devi-
ations $\hat{\phi}_t$ and $\hat{\zeta}_t$. To see how this works, consider another expression for output:

$$y_t = k_t^{\zeta^*_t} (a_t l_t)^{1-\zeta^*_t}.$$  

This equality can be rewritten as

$$\frac{y_t}{y_t} = \frac{k_t^{\zeta^*_t} (a_t l_t)^{1-\zeta^*_t}}{(k_t^*)^{\zeta^*_t} (a_t^* l_t^*)^{1-\zeta^*_t}} = \left( \frac{k_t}{k_t^*} \right)^{\zeta^*_t} \left( \frac{a_t l_t}{a_t^* l_t^*} \right)^{1-\zeta^*_t} k_t^{\tilde{\zeta}_t} (a_t l_t)^{-\tilde{\zeta}_t},$$

and taking logs yields

$$\tilde{y}_t = \zeta^*_t \tilde{k}_t + (1 - \zeta^*_t) (\tilde{a}_t + \tilde{l}_t) + \zeta_t \ln (k_t) - \tilde{\zeta}_t (\ln (l_t) + \ln (a_t))$$

$$\approx \zeta^*_t \tilde{k}_t + (1 - \zeta^*_t) (\tilde{a}_t + \tilde{l}_t) + [\ln (k_t^*) - \ln (l_t)] \tilde{\zeta}_t,$$

as $\ln (a_t^*) = 0$.

To apply this approach to equation (7), we log both sides and implicitly differentiate:

$$\tilde{y}_t = \phi_t^* \zeta^*_t \tilde{k}_t + \phi_t^* (1 - \zeta^*_t) \tilde{a}_t + (1 - \phi_t^*) (\tilde{c}_t + \frac{1}{1 - \zeta_t^*} \tilde{\tau}_t + \frac{1 - \tilde{\tau}_t}{1 + \tilde{\ell}_t^*} \tilde{\ell}_t)$$

$$+ \phi_t^* \ln \left( \frac{k_t^*}{a_t^*} \right) \tilde{\zeta}_t + \left[ \zeta_t^* \ln(k_t^*) + (1 - \zeta_t^*) \ln(a_t^*) + \ln \left( \frac{1}{\chi c_t^*} (1 - \zeta_t^*) (1 - \tilde{\tau}_t^*) (1 + \tilde{\ell}_t^*) \right) \right] \tilde{\phi}_t$$

$$= \phi_t^* \zeta^*_t \tilde{k}_t + \phi_t^* (1 - \zeta^*_t) \tilde{a}_t + (1 - \phi_t^*) (\tilde{c}_t + \frac{1}{1 - \tilde{\tau}_t} \tilde{\tau}_t - \frac{1}{1 + \tilde{\ell}_t} \tilde{\ell}_t)$$

$$+ \left[ \frac{1 - \phi_t^*}{1 - \zeta_t^*} + \phi_t^* \ln (k_t^*) \right] \tilde{\zeta}_t + \left[ \zeta_t^* \ln(k_t^*) + \ln \left( \frac{1}{\chi c_t^*} (1 - \zeta_t^*) (1 - \tilde{\tau}_t^*) (1 + \tilde{\ell}_t^*) \right) \right] \tilde{\phi}_t.$$
expression for total factor productivity, \( \hat{\alpha}_t \). It follows from equation (10) that

\[
\frac{A_t^{1-(\zeta_t^t+\zeta_t^t)}}{(A_t^{t})^{1-\zeta_t^t}} = \frac{A_{at}^{\psi_t^t+\psi_t^t} A_{mt}^{\eta_t^t+\eta_t^t} A_{st}^{\theta_t^t+\theta_t^t}}{A_{at}^* (A_{at}^*)^{\psi_t^t} (A_{mt}^*)^{\eta_t^t} (A_{st}^*)^{\theta_t^t}} \Omega_t \Delta_t
\]

Taking logs yields

\[
(1 - \zeta_t^t) \hat{\alpha}_t - \zeta_t \ln (A_t) = \psi_t^t \hat{\alpha}_{at} + \eta_t^t \hat{\alpha}_{mt} + \theta_t^t \hat{\alpha}_{st} + \hat{\psi}_t \ln (A_{at}) + \hat{\eta}_t \ln (A_{mt}) + \hat{\theta}_t \ln (A_{st})
\]

\[
+ \hat{\alpha}_{at} + \hat{\Omega}_t + \hat{\gamma}_t + \hat{\Delta}_t,
\]

or

\[
\hat{\alpha}_t \approx \frac{1}{1 - \zeta_t} \left( \psi_t^t \hat{\alpha}_{at} + \eta_t^t \hat{\alpha}_{mt} + \theta_t^t \hat{\alpha}_{st} + \ln (A_{at}) \hat{\psi}_t + \ln (A_{mt}) \hat{\eta}_t + \ln (A_{st}) \hat{\theta}_t + \ln (A_{at}^*) \zeta_t^t
\]

\[
+ \hat{\alpha}_{at} + \hat{\Omega}_t + \hat{\gamma}_t + \hat{\Delta}_t \right).
\]

Continuing, it follows from the definition of \( \Omega_t \) that:

\[
\frac{\Omega_t}{\Omega_t^*} = \frac{(1 + \kappa_{mt}^* + \hat{\kappa}_{mt})^{(\eta_t^t + \hat{\eta}_t)\mu} (1 + \kappa_{st}^* + \hat{\kappa}_{st})^{(\theta_t^t + \hat{\theta}_t)\sigma}}{(1 + \kappa_t^* + \hat{\kappa}_t)^{\zeta_t^t + \hat{\zeta}_t}} \cdot \frac{(1 + \kappa_{mt}^*)^{\zeta_t^t}}{(1 + \kappa_{mt}^*)^{\eta_t^t\mu} (1 + \kappa_{st}^*)^{\theta_t^t\sigma}}.
\]

Taking logs, and then implicitly differentiating, yields

\[
\hat{\Omega}_t = \eta_t^t \mu \ln \left( \frac{1 + \kappa_{mt}^* + \hat{\kappa}_{mt}}{1 + \kappa_{mt}^*} \right) + \theta_t^t \sigma \ln \left( \frac{1 + \kappa_{st}^* + \hat{\kappa}_{st}}{1 + \kappa_{st}^*} \right) - \zeta_t^t \ln \left( \frac{1 + \kappa_t^* + \hat{\kappa}_t}{1 + \kappa_t^*} \right)
\]

\[
+ \hat{\eta}_t \mu \ln (1 + \kappa_{mt}^*) + \hat{\theta}_t \sigma \ln (1 + \kappa_{st}^*) + \hat{\eta}_t \mu \ln (1 + \kappa_{mt}^*) + \hat{\theta}_t \sigma \ln (1 + \kappa_{st}^*) - \zeta_t^t \ln (1 + \kappa_t^* + \hat{\kappa}_t)
\]

\[
\approx \eta_t^t \mu \hat{\kappa}_{mt} + \theta_t^t \sigma \hat{\kappa}_{st} - \zeta_t^t \hat{\kappa}_t
\]

\[
+ \mu \ln (1 + \kappa_{mt}^*) \hat{\eta}_t + \sigma \ln (1 + \kappa_{st}^*) \hat{\theta}_t - \ln (1 + \kappa_t^*) \zeta_t.
\]
Similarly,

\[ \tilde{\gamma}_t \approx \frac{\eta_t^* (1 - \mu)}{1 + \ell_{mt}^*} \tilde{\ell}_{mt} + \frac{\theta_t^* (1 - \sigma)}{1 + \ell_{st}^*} \tilde{\ell}_{st} - \frac{1 - \zeta_t^*}{1 + \ell_t^*} \tilde{\ell}_t \]

\[ + (1 - \mu) \ln (1 + \ell_{mt}^*) \tilde{\eta}_t + (1 - \sigma) \ln (1 + \ell_{st}^*) \tilde{\theta}_t + \ln (1 + \ell_t^*) \tilde{\zeta}_t. \]

Finally, it follows from equations (10) and (18) that

\[ \Delta_t A_{ft} \equiv (\alpha^t (1 - \alpha)^{1 - \alpha})^{\psi_t} (\mu^t (1 - \mu)^{1 - \mu})^{\eta_t} (\sigma^t (1 - \sigma)^{1 - \sigma})^{\theta_t} \zeta_t^{t - \zeta_t} (1 - \zeta_t)^{\zeta_t - 1}, \]

so that

\[ \tilde{a}_{ft} + \tilde{\Delta}_t \approx \ln (\alpha^t (1 - \alpha)^{1 - \alpha}) \tilde{\psi}_t + \ln (\mu^t (1 - \mu)^{1 - \mu}) \tilde{\eta}_t + \ln (\sigma^t (1 - \sigma)^{1 - \sigma}) \tilde{\theta}_t \]

\[ - \zeta_t \frac{1}{\zeta_t} \zeta_t - \zeta_t \ln (\zeta_t^* + (\zeta_t^* - 1) \frac{1}{1 - \zeta_t^*} (-\zeta_t) + \zeta_t \ln (1 - \zeta_t^* \zeta_t^* \ln (1 - \zeta_t^* \zeta_t^* \ln (1 - \zeta_t^*) \]

\[ = \ln (\alpha^t (1 - \alpha)^{1 - \alpha}) \tilde{\psi}_t + \ln (\mu^t (1 - \mu)^{1 - \mu}) \tilde{\eta}_t + \ln (\sigma^t (1 - \sigma)^{1 - \sigma}) \tilde{\theta}_t \]

\[ + \ln \left( \frac{1 - \zeta_t^*}{\zeta_t^*} \right) \tilde{\zeta}_t. \]

Next, we consider the sectoral distortions, \( \kappa_t \) and \( \ell_t \). Recall the capital distortion:

\[ \kappa_t = \frac{1}{\zeta_t} \left[ \eta_t \mu \kappa_{mt} + \theta_t \sigma \kappa_{st} \right]. \]
Implicit differentiation yields

\[
\hat{\kappa}_t \approx \frac{1}{\zeta^*_t} \left[ \mu \kappa^*_m \hat{\eta}_t + \eta^*_t \mu \hat{\kappa}_m + \sigma \kappa^*_m \hat{\theta}_t + \theta^*_t \sigma \hat{\kappa}_s \right] - \frac{1}{(\zeta^*_t)^2} \left[ \eta^*_t \mu \kappa^*_m + \theta^*_t \sigma \kappa^*_s \right] \hat{\zeta}_t
\]

\[
= \frac{1}{\zeta^*_t} \left[ \mu \kappa^*_m \hat{\eta}_t + \eta^*_t \mu \hat{\kappa}_m + \sigma \kappa^*_m \hat{\theta}_t + \theta^*_t \sigma \hat{\kappa}_s - \kappa^*_t \hat{\zeta}_t \right].
\]

Similarly

\[
\hat{\ell}_t \approx \frac{1}{1 - \zeta^*_t} \left[ (1 - \mu) \ell^*_m \hat{\eta}_t + \eta^*_t (1 - \mu) \hat{\ell}_m + (1 - \sigma) \ell^*_s \hat{\theta}_t + \theta^*_t (1 - \sigma) \hat{\ell}_s + \ell^*_t \hat{\zeta}_t \right].
\]

Finally, we express the composite parameters \( \zeta_t \) and \( \phi_t \) as functions of the share parameters \( \psi_t, \eta_t \) and \( \theta_t \). Recall that

\[
\zeta_t \equiv \alpha \psi_t + \mu \eta_t + \sigma \theta_t,
\]

\[
\phi_t \equiv \frac{1 + \gamma}{\gamma + \zeta_t},
\]

\[
1 = \psi_t + \eta_t + \theta_t,
\]

yielding

\[
\hat{\zeta}_t \equiv \alpha \hat{\psi}_t + \mu \hat{\eta}_t + \sigma \hat{\theta}_t,
\]

\[
\hat{\phi}_t \equiv -\frac{1 + \gamma}{(\gamma + \zeta^*_t)^2} \hat{\zeta}_t,
\]

\[
\hat{\eta}_t = -\hat{\psi}_t - \hat{\theta}_t.
\]
A.5 Solving Time-Varying Linear Expectational Difference Equations

Our approach most closely follows that of Klein (2000) (and to a lesser extent Sims, 2002), although we use the eigenvalue-eigenvector decomposition introduced by Blanchard and Kahn (1980) (as well as their notation), rather than the generalized Schur decomposition. We also incorporate elements of the MDS approaches used by Broze, Gourieroux and Szafarz (1985, 1995), Farmer (1993) and Farmer and Guo (1994), as well as insights from King, Plosser and Rebelo (2002).

A.5.1 The basic solution

Consider the following system:

\[ E_t (v_{t+1}) = A_t v_t, \quad t = 0, 1, 2, ..., \]  

(8)

where \( v_t \) is an \((n \times 1)\) vector, \( A_t \) is an \((n \times n)\) time-dependent matrix, and \( E_t (.) \) is the usual conditional expectations operator. The vector \( v_t \) can be decomposed into the \((n_1 \times 1)\) control vector \( x_t \) and the \((n_2 \times 1)\) state vector \( p_t \). In particular, \( p_t \) is restricted by

\[ d_{t+1} \equiv p_{t+1} - E_t (p_{t+1}) \text{ given}, \quad t = 0, 1, 2, ..., \]  

(9)

\( p_0 \) given,
where \( \{ d_{t+1} \}_{t=0}^{\infty} \) is a covariance stationary Martingale difference sequence. In contrast, \( x_t \) needs only to obey some standard boundedness conditions; \( g_{t+1} \equiv x_{t+1} - E_t(x_{t+1}) \) is otherwise unrestricted. Using these definitions, we can rewrite equation (8) as

\[
\begin{pmatrix}
  x_{t+1} \\
  p_{t+1}
\end{pmatrix} = A_t \begin{pmatrix}
  x_t \\
  p_t
\end{pmatrix} + \begin{pmatrix}
  g_{t+1} \\
  d_{t+1}
\end{pmatrix}, \quad t = 0, 1, 2, \ldots
\]

subject to the restrictions in equation (9). In our case, the control vector \( x_t \) has one variable, the consumption deviation \( \tilde{c}_t \), so that \( n_1 = 1 \). The remaining variables, the capital and wedge deviations, are elements of \( p_t \).

The next step is to diagonalize \( A_t \):

\[
A_t = B_t J_t C_t,
\]

where: the matrix \( B_t \) contains the eigenvectors of \( A_t \); the matrix \( J_t \) is a diagonal matrix holding the associated eigenvalues; and \( C_t = B_t^{-1} \). (In our case, a simple diagonalization always works.) Assume that the eigenvalues are sorted by size in descending order, and let \( m_1 \) denote the number of eigenvalues of magnitude greater than 1. In the standard saddle-path case, \( m_1 = n_1 \). We will hold this assumption throughout our analysis; readers interested in other configurations can consult the references listed above. With saddle-path stability, we can partition \( B_t, J_t, \) and \( C_t \),
As:

\[
B_t = \begin{bmatrix}
B_{1t} & B_{2t} \\
(n \times n_1) & (n \times n_2)
\end{bmatrix} = \begin{bmatrix}
B_{11t} & B_{12t} \\
(n_1 \times n_2) & (n_1 \times n_2)
\end{bmatrix},
\]

\[
J_t = \begin{bmatrix}
J_{1t} & 0 \\
(n_1 \times n_1) & (n_1 \times n_2)
\end{bmatrix},
\]

\[
C_t = \begin{bmatrix}
C_{1t} \\
(n_1 \times n_1)
\end{bmatrix},
\]

Premultiplying equation (10) by \(C_t\) yields the transformed system

\[
\tilde{w}_{t+1} = \begin{bmatrix}
\tilde{y}_{t+1} \\
\tilde{q}_{t+1}
\end{bmatrix} = \begin{bmatrix}
J_{1t} & 0 \\
0 & J_{2t}
\end{bmatrix} \begin{bmatrix}
y_t \\
q_t
\end{bmatrix} + \begin{bmatrix}
\tilde{h}_{t+1} \\
\tilde{e}_{t+1}
\end{bmatrix}, \quad t = 0, 1, 2, \ldots, \quad (11)
\]

\[
y_t = C_{1t} v_t; \quad q_t = C_{2t} v_t,
\]

\[
\tilde{y}_{t+1} = C_{1t} \tilde{v}_{t+1}; \quad \tilde{q}_{t+1} = C_{2t} \tilde{v}_{t+1},
\]

\[
\tilde{h}_{t+1} = C_{1t} \begin{bmatrix}
g_{t+1} \\
d_{t+1}
\end{bmatrix}; \quad \tilde{e}_{t+1} = C_{2t} \begin{bmatrix}
g_{t+1} \\
d_{t+1}
\end{bmatrix}.
\]

Because the timing of the transformation is important, we use tildes to denote transformed variables with time “mismatches”.

Because the elements of \(J_{1t}\) are bigger than 1 in magnitude, the non-explosive
solution to the first row of equation (11) is to set

\[ y_t = \tilde{h}_{t+1} = \tilde{y}_{t+1} = 0. \]

It immediately follows that

\[ v_t = B_tw_t = B_{2t}w_t, \]

\[ v_{t+1} = B_{2t}\tilde{w}_{t+1}, \]

\[ \begin{pmatrix} f_{t+1} \\ d_{t+1} \end{pmatrix} = B_{2t}\tilde{e}_{t+1} = \begin{bmatrix} B_{12t} \\ B_{22t} \end{bmatrix}\tilde{e}_{t+1}. \]

But because \( d_{t+1} \) is given, it must be the case that

\[ B_{22t}\tilde{e}_{t+1} = d_{t+1}, \]

\[ \tilde{e}_{t+1} = B_{22}^{-1}d_{t+1}, \]

and

\[ \begin{pmatrix} f_{t+1} \\ d_{t+1} \end{pmatrix} = H_t d_{t+1}, \quad (12) \]

\[ H_t \equiv \begin{bmatrix} B_{12t}B_{22}^{-1} \\ I_{n_2} \end{bmatrix}, \]

where \( I_{n_2} \) is an identity matrix of size \( n_2 \).
A.5.2 The effects of time variation

Equation (12) implies that the innovation to the control variable $x_t$ is a linear function of the innovations to the state variable $p_t$. The same logic, however, applies to the variables $x_t$ and $p_t$ themselves. The fact that $p_t$ is pre-determined at time $t$, along with the non-explosiveness restriction $y_t = 0$, implies that

$$
\begin{pmatrix}
x_t \\
p_t
\end{pmatrix} = H_t p_t.
$$

Comparing equations (12) and (13) reveals a timing inconsistency: time-$t$ innovations are “stabilized” using time-$t - 1$ coefficients, while the variables themselves are stabilized using time-$t$ coefficients. To see how this plays out, consider the system:

$$
\begin{pmatrix}
x_{t+1} \\
p_{t+1}
\end{pmatrix} = A_t \begin{pmatrix}
x_t \\
p_t
\end{pmatrix} + H_t d_{t+1}.
$$

Suppose further that: $v_0 = 0$; $d_t = 0$, $\forall t \neq 1$; and $d_1 \neq 0$. This yields:

$$
\begin{align*}
v_0 &= 0, \\
v_1 &= H_0 d_1, \\
v_2 &= A_1 v_1 = A_1 H_0 d_1, \\
v_3 &= A_2 A_1 H_0 d_1
\end{align*}
$$
But it should also be the case that

\[ v_2 = A_1 H_1 p_1 = A_1 H_1 d_1. \]

Following Klein (2000), we can show that equation (13) generates a bounded solution. In particular,

\[
A_t H_t = \begin{bmatrix} B_{1t} & B_{2t} \end{bmatrix} \begin{bmatrix} J_{1t} & 0 \\ 0 & J_{2t} \end{bmatrix} \begin{bmatrix} C_{1t} \\ C_{2t} \end{bmatrix} H_t
\]

\[ = (B_{1t} J_{1t} C_{1t} + B_{2t} J_{2t} C_{2t}) H_t. \]

Moreover,

\[
H_t = \begin{bmatrix} B_{12t} B_{22t}^{-1} \\ I_{n_2} \end{bmatrix} = \begin{bmatrix} B_{12t} \\ B_{22t} \end{bmatrix} B_{22t}^{-1} = B_{2t} B_{22t}^{-1}.
\]

As a result,

\[
A_t H_t = (B_{1t} J_{1t} C_{1t} + B_{2t} J_{2t} C_{2t}) B_{2t} B_{22t}^{-1}
\]

\[ = (B_{1t} J_{1t} 0 + B_{2t} J_{2t} I_{n_2}) B_{22t}^{-1}
\]

\[ = B_{2t} J_{2t} B_{22t}^{-1}, \]

because, as noted by Klein (2000, p. 1418), \( C_t B_t = I \).

Note that

\[ A_t H_t = A_t^* H_t, \]
where the "stabilized" transition matrix $A^*_t$ has been purged of its explosive eigenvalues:

$$A^*_t = \begin{bmatrix} B_{1t} & B_{2t} \\ 0 & 0 \\ 0 & J_{2t} \\ C_{1t} & C_{2t} \end{bmatrix} = B_{2t}J_{2t}C_{2t}.$$

In short, applying equation (13) is equivalent to updating equation (10) with a non-explosive transition matrix. This result does not hold if we use $H_{t-1}$ from equation (12), as $A_t$ contains $C_{1t}$, while $H_{t-1}$ contains $B_{2t-1}$. On the other hand, using equation (12) bests captures the transition dynamics in effect at time $t$. Our solution is this:

1. Given $p_t$, use equation (13) to find $x_t$.

2. Given $(x'_t, p'_t)'$, use the bottom $n_2$ rows of equation (10) or (14) to find $p_{t+1}$.

Return to step 1.

Using this approach means that $x_{t+1}$ is not entirely consistent with the dynamics implied by equations (10) or (14). In our context, this means that consumption does not perfectly satisfy the linearized Euler equation. The error appears to be less than 1 percent of consumption, however, which is small relative to some observed parameter changes.
A.6 Estimated and Projected Trends

Figure A1. Estimated and Projected Trends: Sectoral Shares

Figure A2. Estimated and Projected Trends: Sector-Specific Total Factor Productivity
Figure A3. Estimated and Projected Trends: Capital and Labor Market Distortions

Figure A4. Estimated and Projected Trends: Fiscal Policies and Depreciation Rate
Appendix: Construction of Service Policy Reform

Index

Telecommunications

<table>
<thead>
<tr>
<th>Step</th>
<th>Year of achievement in India and accomplishments indicating reform progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Clear public sector dominance with no private sector involvement. At most announcement of future private sector role strong political interference in management decisions low tariffs and extensive cross-subsidies. 1993/94 The first private netwroks in industrial areas were licensed and put in operations. Licensing process for cellular service begins, envisaging the possibility for foreign participation.</td>
</tr>
<tr>
<td>1</td>
<td>Some first instances of private sector involvement, but limited to particular segments of the market. Some liberalization of operational decisions where private sector is involved. At most there is talk about allowing foreign presence, but not yet in operation. 1994/95 Private cellular service providers emerge in major cities, all of which have some foreign equity. Process of issuing further licenses to private sector begins. New Telecom Policy announced to define framework for further private sector participation. FDI possible up to 49 percent.</td>
</tr>
<tr>
<td>2</td>
<td>Private participation begins in important segments of the market, most likely the cellular segment (which tends to be the first one to rely on private participation). In these segments, public interference with operational decisions is limited. There is clearly defined scope for foreign participation, but with certain limits. In other segments, the public sector remains dominant, with fixed-line tariffs still politically set. 1999/00 New Telecom Policy issued which defines the way ahead for a complete opening of national and international long distance market. Regulator strengthened, licensing fee arrangement made more favorable for private operators.</td>
</tr>
<tr>
<td>3</td>
<td>Significant scope for private providers, including foreign ones, beyond one segment of the market. Some competitive pressure on pre-reform fixed line incumbent. Explicit possibilities of foreign equity participation. 2002/03 National long distance market fully open with no restrictions on the number of operators. Public monopoly in international gateways abolished.</td>
</tr>
<tr>
<td>4</td>
<td>Hardly any public intervention in cellular and value added services, where the private sector is dominant and foreign investors significantly present. Free entry into relevant segments of the fixed line market. Comprehensive regulatory and institutional reforms.</td>
</tr>
<tr>
<td>5</td>
<td>Private sector providers dominate in almost all segments. Effective regulation through independent regulator including a coherent framework to deal with interconnection and licensing. Effective competition in most segments of the market with unrestricted entry.</td>
</tr>
</tbody>
</table>

## Transport

<table>
<thead>
<tr>
<th>Step</th>
<th>Year of achievement in India and accomplishments indicating reform progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Little progress, public sector is the sole provider of all infrastructure, and has dominant stakes in several segments of the transport. Where the public sector is not an operator such as in road transport, it regulates operations heavily.</td>
</tr>
<tr>
<td>1</td>
<td>Increased scope for private sector participation in some segments of the sector. Some liberalization of operational decisions. Some limited scope for foreign participation in service provision. At most there is talk about allowing foreign presence, but not yet in operation. 1993/94 Abolition of the formal monopoly in domestic air services, entry into domestic air services. Liberalization of prices in maritime freight and passenger transport. Explicit recognition of the possibility to levy user fees on national highways, which was considered a precondition for private engagement.</td>
</tr>
<tr>
<td>2</td>
<td>Private participation begins in important segments of the market. In these segments, public interference with operational decisions is limited. There is clearly defined scope for foreign participation, but with certain limits. In other segments, the state remains the dominant actor. 1997/98 FDI in air transport up to 40 percent is allowed (although foreign airlines are excluded). Majority FDI possible in the construction and operation of ports. First private sector engagement in road infrastructure under the &quot;Build, Operate, Transfer&quot; scheme.</td>
</tr>
<tr>
<td>3</td>
<td>Significant scope for private providers, including foreign ones, beyond one segment of the market. Some competitive pressure on public sector operations. Explicit possibilities for foreign equity participation. 2004/05 Private airlines permitted to serve international routes. Both public sector airlines feel significant competitive pressure from private competitors.</td>
</tr>
<tr>
<td>4</td>
<td>Important segments are almost free of public intervention, with private sector operators being dominant and significant foreign engagement present. Free entry into relevant segments of the transport market. -</td>
</tr>
<tr>
<td>5</td>
<td>Private sector providers dominate in almost in almost all segments. Effective competition in most segments of the market with unrestricted entry. Equal treatment of foreign and domestic providers. -</td>
</tr>
</tbody>
</table>

Source: Arnold et al. (2008)
### Banking

<table>
<thead>
<tr>
<th>Step</th>
<th>Year of achievement in India and accomplishments indicating reform progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Little progress, public sector plays the dominant role. Where there are private operators, their operations and scope of services on offer are tightly regulated.</td>
</tr>
<tr>
<td>1</td>
<td>Increased scope for private sector participation. Some liberalization of operational decisions, but directed lending remains prevalent. Some limited scope for foreign participation in domestic banks. Legislation passed to signal government’s in-principle approval of the new private entry into banking sector. 7 new banks enter the market. FDI up to 20 percent but foreign banks are barred. Banks given more freedom to allocate their inventories and receivable across different firms.</td>
</tr>
<tr>
<td>2</td>
<td>Significant private participation becomes possible. Public interference with operational decisions and discretionary barriers to entry are limited. There is clearly defined scope for foreign participation, but with certain limits. The state remains a dominant actor. Discretionary barriers to entry into banking sector are lowered significantly. State signals its intent to eventually withdraw from the banking sector.</td>
</tr>
<tr>
<td>3</td>
<td>Significant scope for private banks, including explicit possibilities for foreign equity participation. Some competitive pressure on public sector operations. Major interest rate deregulation allows banks to set prices more freely. Private sector banks gain more relevance as lenders and begin to crowd out public sector banks in some instances.</td>
</tr>
<tr>
<td>4</td>
<td>Important segments are almost free of public intervention, with private sector operators being dominant and significant foreign engagement present. Free entry into relevant segments of the transport market. Majority foreign ownership is possible. Foreign participation in Indian banks is made significantly easier. Clearance for up to 49 percent of equity is automatic, and majority ownership is possible subject to case-wise approval.</td>
</tr>
<tr>
<td>5</td>
<td>Private sector providers dominate in almost all segments. Effective competition in most segments of the market with unrestricted entry. Equal treatment of foreign and domestic providers. Full convergence of regulation with international standards.</td>
</tr>
</tbody>
</table>

Source: Arnold et al. (2008)
## Insurance

<table>
<thead>
<tr>
<th>Step</th>
<th>Year of achievement in India and accomplishments indicating reform progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Little progress, public sector plays the dominant role.</td>
</tr>
<tr>
<td>1</td>
<td>Increased scope for private sector participation. Some liberalization of operational decisions, but still massive interventions. Some limited scope for foreign participation but low FDI ceilings. 1999/00 Bill passed to open up the insurance sector to private entry, including foreign equity participation up to 26 percent. Substantial freedom with respect to pricing, but strict regulatory supervision. Discretionary entry permission was required and no acquisitions possible due to public sector dominance.</td>
</tr>
<tr>
<td>2</td>
<td>Significant private participation becomes possible. Public interference with operational decisions and discretionary barriers to entry are limited. There is clearly defined scope for foreign participation, but with certain limits. The state remains a dominant actor. -</td>
</tr>
<tr>
<td>3</td>
<td>Significant scope for private banks, including explicit possibilities for foreign equity participation. Some competitive pressure on public sector operators. 2002/03 Entry of 12 new private providers of insurance services, which constitutes a massive shake-up of the market. Competitive pressure on incumbent public insurers. FDI ceiling remains at 26 percent.</td>
</tr>
<tr>
<td>4</td>
<td>Most operational decisions are almost free of public intervention, with private sector operators being dominant and significant foreign engagement present. Free entry into relevant segments of the market. Majority foreign ownership is possible. -</td>
</tr>
<tr>
<td>5</td>
<td>Private sector providers dominate. Effective competition in most segments of the market with unrestricted entry. Equal treatment of foreign and domestic providers. Wide array of insurance services available at competitive prices. Full convergence of regulation with international standards. -</td>
</tr>
</tbody>
</table>

Source: Arnold et al. (2008)
## Business services (IT)

<table>
<thead>
<tr>
<th>Step</th>
<th>Year of achievement in India and accomplishments indicating reform progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Clear public sector dominance with no private sector involvement</td>
</tr>
<tr>
<td>1</td>
<td>Some first instances of private sector involvement, but limited to particular segment of the market.</td>
</tr>
<tr>
<td>2</td>
<td>Private participation begins in important segments of the market.</td>
</tr>
<tr>
<td></td>
<td>Software technology parks set up in different cities, each of which provided satellite links to be used by firms with wireless connections to them. In 1993, government began to allow private dedicated links as well. Computers were freed from import licensing and import duties were reduced.</td>
</tr>
<tr>
<td>3</td>
<td>Significant scope for private providers, including foreign ones, beyond one segment of the market.</td>
</tr>
<tr>
<td>4</td>
<td>Private sector is dominant and foreign investors significantly present.</td>
</tr>
<tr>
<td>5</td>
<td>Private providers dominate. No entry barriers for foreign firms. Domestic and foreign firms are treated equally.</td>
</tr>
</tbody>
</table>