Sectoral Infrastructure Investments in an Unbalanced Growing Economy: The Case of Potential Growth in India

CHETAN GHATE, GERHARD GLOMM, AND JIALU LIU STREETER*

We construct a two-sector (agriculture and modern) overlapping generations growth model calibrated to India to study the effects of sectoral tax rates, sectoral infrastructure investments, and labor market frictions on potential growth in India. Our model is motivated by the idea that because misallocation depends on distortions, policies that reduce distortions raise potential growth. We show that the positive effect of a variety of policy reforms on potential growth depends on the extent to which public and private capital are complements or substitutes. We also show that funding more infrastructure investments in both sectors by raising labor income taxes in the agriculture sector raises potential growth.

Keywords: Indian economic growth, misallocation, public capital, structural transformation, two-sector OLG growth models, unbalanced growth
JEL codes: H21, O11, O20, O41

I. Introduction

How do sectoral tax policies and labor laws distort the sectoral allocation of labor and capital to prevent developing economies from realizing their growth potential? Lewis (1954) famously argued that economic development means growth of the modern sector. If so, what prevents the development and expansion of the modern sector in growing economies? What are the impediments to the reallocation of labor to sectors of high productivity? Will a tax on agriculture income that funds higher public investment inhibit the rise of the modern sector? These questions have policy importance as distortions in the agriculture and the nonagriculture (modern) sectors constrain growth in developing economies by preventing the full productivity effect of factor reallocation.

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We address these questions within the context of an unbalanced growing economy, India, that is undergoing fundamental changes in the structure of production and employment. We build a two-sector overlapping generations (OLG) neoclassical growth model calibrated to India. The two sectors are an agriculture sector and a modern (nonagriculture) sector that merges the manufacturing and service sectors together.[1] In our model, all individuals work when young and retire when old. Individuals pay taxes on their labor income in both sectors, and receive an excise subsidy for the consumption of agriculture products. The remaining tax revenues are allocated as infrastructure investments across both sectors. In each sectoral production technology, the stock of public infrastructure is a productive input, and is combined with sector specific capital and labor in accordance with a constant elasticity of scale (CES) production function. Public and private capital can be complements or substitutes. To incorporate the drag on modern sector output because of the presence of labor laws, we subtract a term that increases proportionately with the amount of labor employed in the modern sector. We think of this loss occurring because of bureaucratic problems related to a large labor force in the modern sector. Labor and capital are assumed to be perfectly mobile across sectors.

Given this setup, we show that exogenous fiscal policies (sectoral taxes and subsidies) and labor market frictions can play an important role in misallocating factors of production, which affects potential growth. Since less misallocation would suggest that the economy can produce more with the same factors of production and production technology, policy reforms that induce greater efficiency are key to understanding India's growth and growth potential.

A. India's Pattern of Structural Transformation

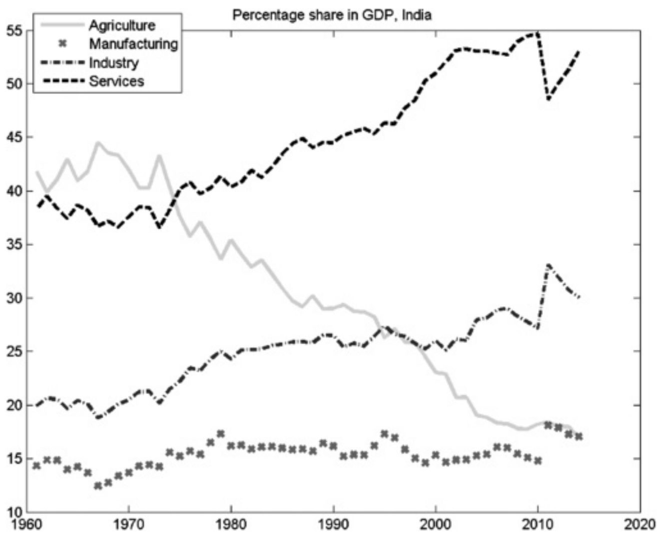
Most economies have undergone substantial structural changes that involved shifts of resources across the agriculture, manufacturing, and service sectors, and very large changes in the capital–output ratios of all three sectors. In the context of the development process, India stands out for three reasons.[2] As can be seen from Figure 1, India's service sector has grown rapidly in the last 3 decades, constituting 55% of the gross domestic product (GDP) in 2010, with a share close to 53% in 2015.[3] The large size of the service sector in India is comparable to the size of the service sector in developed economies where services often provide more than 60% of total output and an even larger share of employment. Since many components

[1] This identification is not necessary as we just need two sectors whose output and employment shares in the total economy rise and fall, respectively, and whose capital–output ratios are not constant over relatively long time horizons.

[2] These structural shifts are documented in Verma (2012).

[3] Industry comprises value added in mining, manufacturing, construction, electricity, and water and gas. In 2014, value added in industry was 30% of GDP. Manufacturing value added was 17% of GDP, comprising approximately 57% of industry's share.

Figure 1. **Structural Transformations in India**



GDP = gross domestic product.
Source: World Bank. World Development Indicators. http://data.worldbank.org/indicator/

of services (e.g., financial services, business services, hotels, and restaurants) are income related and increase only after a certain stage of development, the fact that India's service sector is very large relative to its level of development is puzzling.

Second, the entire decline in the share of agriculture in India's GDP in the last 2 decades has been accounted for by an expanding service sector. The manufacturing sector's share of GDP has stayed constant at around 15% of GDP over the past 30 years.[4] In general, such a trend is experienced by high-income economies and not by developing economies. In developing economies, the typical pattern is for the manufacturing sector to replace the agriculture sector's declining share of GDP initially. Only at higher levels of aggregate income does the service sector play an increasingly large role. In addition, in spite of the rising share of services in both GDP and trade, there has not been a corresponding rise in the share of services in India's total employment. In other words, India's service sector has not been sufficiently employment generating.[5]

[4]In comparison, in 2010, manufacturing value added as a percentage of GDP was 29.5% in the People's Republic of China, 24.8% in Indonesia, 24.5% in Malaysia, and 33.6% in Thailand (UN National Account Statistics 2015). Gupta and Kumar (2012) provide a comprehensive review of the factors inhibiting India's manufacturing sector in the postreform period. Hsieh and Klenow (2009) show that firm heterogeneity in productivity and distortions have led to misallocation in Indian firms.

[5]While there will always be issues with modeling three disparate sectors such as services, manufacturing, and agriculture, one can think of agriculture in our model—and other models of economic transformation—as being the one truly traditional sector and the rest of the economy as the more modern sector. These models typically capture the shrinking of the agriculture sector as the economy develops.

Table 1. **Data on Structural Transformation in India, 1970–2000**

Variable	Agriculture 1970	Agriculture 2000	Manufacturing 1970	Manufacturing 2000	Services 1970	Services 2000
$\frac{Employment}{Share}$	77%	62%	12%	19%	12%	20%
$\frac{GDP}{Share}$	48%	25%	23%	27%	29%	48%
K/Y Ratio	3.3	0.9	0.6	4.3	11.0	1.8
$\frac{Gross}{Capital\ Formation}$	18%	9%	33%	30%	49%	61%

GDP = gross domestic product.
Note: "K/Y Ratio" refers to the capital–output ratio.
Source: Verma. 2012. Structural Transformation and Jobless Growth in the Indian Economy. In C. Ghate, ed. *The Oxford Handbook of the Indian Economy*. Oxford University Press: New York.

Third, unlike the case of aggregate data in advanced economies where capital–output ratios are often constant over time, the sectoral capital–output ratios in India exhibit large changes over time (Table 1).[6] While agriculture's capital–output ratio fell from 3.3 to 0.9 between 1970 and 2000, the manufacturing sector's capital–output ratio rose from 0.6 to 4, and the service sector's capital–output ratio fell from 11 to 1.8.

Figure 2 shows agriculture employment in Brazil, the People's Republic of China, and India during 1980–2015. What is apparent is that the relative decline of agriculture's share of employment is slower in India than in these economies. Taking Figure 1 and Figure 2 together, what stands out is that the changes in India's GDP structure are asymmetric to its sectoral employment intensity.

Figure 3 shows that when measured in constant 2005 United States dollars, the growth of India's GDP has risen persistently since 1980.

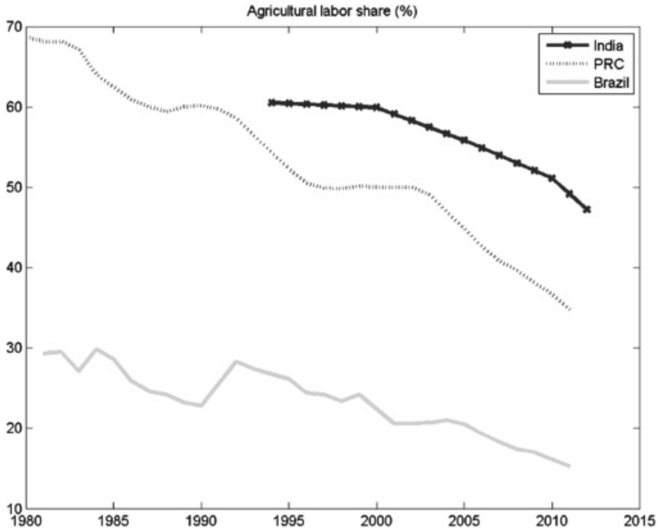
B. Description of the Main Results

The observations in the previous section suggest that, in the context of India over the last 50 years, the balanced growth assumption does not seem appropriate. First, the growth rate of GDP seems to be increasing over the sample period. Moreover, the transition out of agriculture seems to have accelerated after 1975. We therefore abandoned the strategy of balanced growth and instead pursued a strategy of matching the transition out of agriculture with growth in the modern sector (manufacturing and services).[7] In our model, growth will not be balanced since the production technologies do not exhibit constant returns in all the augmentable

[6] See Verma (2012).

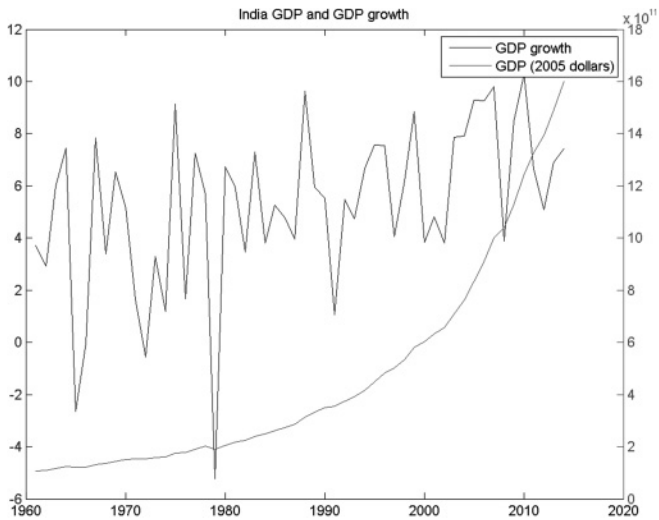
[7] In models of capital accumulation, balanced growth typically prevails when there are constant returns to all augmentable factors. In such a case, all variables that can grow will grow at the same constant rate forever, and all variables that are bounded are constant over time. In growth models of structural transformation such as Gollin, Parente, and Rogerson (2002), balanced growth in the sense defined above typically is not obtained since the perpetual shifting of resources from the traditional to the modern sector prevents the growth rate of GDP from being constant over time. It is still possible, however, to define something like balanced growth in terms of a constant rate of labor migration from the traditional to the modern sector.

Figure 2. **Agriculture Employment in Select Emerging Market Economies**



PRC = People's Republic of China.
Source: World Bank. World Development Indicators. http://data.worldbank.org/indicator/

Figure 3. **Indian GDP and GDP Growth (Constant 2005 Prices)**



GDP = gross domestic product.
Source: World Bank. World Development Indicators. http://data.worldbank.org/indicator/

factors. In our model, both physical and infrastructure capital are augmentable. The labor's share of value added differs across the two sectors, so the returns to the two augmentable factors differ across the two sectors as well. It is this difference in the returns to augmentable factors that helps us match the transition out of agriculture into the modern sector. This transition will generally be neither constant nor balanced.

Our baseline calibrations capture some of the observations discussed in Figures 1–3 for India fairly closely over a 30-year period. For instance, GDP per capita increases persistently, as is shown in Figure 3. Second, consistent with the observations in Table 1, the agriculture sector is shrinking over time: its employment share drops from 67% to 40%. The drop in agriculture's share of GDP is relatively larger from 56% to 30%. These drops are largely consistent with the asymmetry in the data in Table 1, which show that agriculture's share of GDP in the Indian data falls more rapidly than its employment share.

Given that the baseline model captures unbalanced growth in India qualitatively, we use the calibrated version of the model to conduct a variety of counterfactual policy experiments on (i) the sectoral allocation of public infrastructure investment between the agriculture and modern sectors, (ii) changes in sectoral tax rates and subsidies, and (iii) changes in the drag created by labor market friction to increase potential growth. Our first result addresses how public capital should be allocated between the agriculture and modern sectors to influence India's growth potential. We show that a major policy reform that increases the sectoral allocation of public capital to the agriculture sector leads to smaller effects on overall GDP when public and private capital are substitutes, rather than complements. When public and private capital are substitutes, an increase (decrease) in public capital is followed by a decrease (increase) in private capital, thus undoing the effects of policy change. In the case of complements, a reinforcing effect takes place that magnifies the policy effects.

Second, we show that increasing the agricultural income tax rate and using the extra tax revenue to fund increased investment in infrastructure in both sectors leads to a large and persistent increase in GDP. When the same experiment is conducted with an identical rise in the modern sector's tax rate, the substitutability between private and public capital induces larger shifts in labor across the sectors, which translates into a larger decline in modern sector output, which in turn, causes a larger decline in overall GDP.

Third, we find that an increase in the subsidies for the agriculture goods shifts demand away from the modern sector to the agriculture sector. This shift drags down potential growth and decreases overall GDP.

To incorporate the drag on the modern sector's output caused by the presence of labor laws, following Das and Saha (2015), we subtract a term that increases proportionately with the amount of labor employed in the modern sector. We think of this loss occurring because of bureaucratic problems related to a large labor force in the modern sector. We show that increasing the regulatory drag—or labor market frictions—decreases wages in the modern sector and this shifts employment to agriculture. There is a drop in output in both the modern and the agriculture sectors, with the drop in the modern sector being larger. Since both sectoral outputs decline, overall GDP declines as well. These results are very similar when public and private capital are substitutes. This is a new interpretation of the effect of labor market frictions on sectoral infrastructure investments. Typically in the literature, labor market frictions are seen to employ inefficient labor in the modern sector (see, for example, Gupta and Kumar 2012) or to constrain growth by deterring entry and skewing firm-size distribution (see, for example, Alfaro and Chari 2014). In our model, labor market frictions depress potential output by pulling productive resources out of the modern sector. A lower value of the labor market friction parameter leads to higher efficiency, suggesting that policies that diminish labor market distortions can affect potential growth.

C. Literature Review

Our paper builds on the literature in the field of growth and development. There is a large body of literature that studies how structural change and growth are related in the development process, including Caselli and Coleman (2001); Glomm (1992); Gollin, Parente, and Rogerson (2002); Laitner (2000); and Lucas (2004). However, there has been relatively little work within this literature focusing on developing economies in general and India in particular.

There is also a large body of literature studying the effects of infrastructure investment on economic growth. Usually these types of analyses are carried out in a one-sector growth model with an aggregate production function, often of the Cobb–Douglas kind. Examples here include Barro (1990); Turnovsky and Fischer (1995); Turnovsky (1996); Glomm and Ravikumar (1994, 1997); Eicher (2000); Agénor and Moreno-Dodson (2006); Agénor (2008); Ott and Turnovsky (2006); and Angelopoulos, Economides, and Kammas (2007); among others. There are also many empirical studies to go along with the above theoretical investigations. Examples of such empirical papers include Barro (1990), Ai and Cassou (1995), Holtz-Eakin (1994), and Lynde and Richmond (1992).[8] To the extent that infrastructure is often seen as being strategic to development, these papers do not discuss how infrastructure spending should be financed across sectors or whether the agriculture sector should be taxed.

II. The Model

The economy in our model is populated by an infinite number of generations. Each generation is alive for two periods, young age and old age, and each accounts for

[8]Combining these two areas of growth and development research, there is a smaller body of literature that analyzes the effects of infrastructure investment in economies undergoing structural changes such as large shifts of productive activity from agriculture to manufacturing and then to services. Examples include Arcalean, Glomm, and Schiopu (2012); Carrera, Freire-Seren, and Manzano (2009); de la Fuente et al. (1995); Caminal (2004); and Ott and Soretz (2010).

25 years. All individuals work when young and retire when old. Within a generation, all individuals are identical. For simplicity, we assume that all individuals consume only in the second period of life.[9] Thus, all income from the first period is saved for consumption when old. There are two sectors: one we call "agriculture" and a second sector we call "modern," although the names are not crucial. What is crucial is that there are two sectors, with one sector declining and one sector increasing along the development path. The utility function for all households is given below:

$$u(c_{m,t+1}, c_{a,t+1}) = lnc_{m,t+1} + \phi lnc_{a,t+1}, \quad \phi > 0 \tag{1}$$

where $c_{m,t+1}$ denotes household consumption of the modern sector good and $c_{a,t+1}$ the consumption of the agriculture good.

Households working in the agriculture and modern sectors solve the following problem:

$$\begin{aligned} \max_{c_m, c_a} \quad & lnc_{m,t+1} + \phi lnc_{a,t+1} \\ s.t. \quad & c_{m,t+1} + (1-\xi)p_{t+1}c_{a,t+1} = (1-\tau_a)w_{a,t}(r_t + 1 - d) \quad \text{Agriculture} \\ & c_{m,t+1} + (1-\xi)p_{t+1}c_{a,t+1} = (1-\tau_m)w_{m,t}(r_t + 1 - d) \quad \text{Modern} \end{aligned} \tag{2}$$

where $0 < \xi < 1$ is a government subsidy on agriculture goods consumption and $\tau_a \in [0, 1]$ and $\tau_m \in [0, 1]$ are tax rates levied on labor income in the agriculture and modern sectors, respectively. r_t represents the rental price of capital. d is the depreciation rate of capital, $w_{a,t}$ is the wage rate in the agriculture sector, and $w_{m,t}$ is the wage rate in the modern sector. We assume that the modern sector good is the numeraire, and so p_t denotes the relative price of the agriculture good relative to the modern sector good.[10] Since households only consume in the second period, aggregate consumption for the agriculture good, $c_{a,t+1}$, and the modern sector good, $c_{m,t+1}$, satisfies

$$\frac{c_{a,t+1}}{c_{m,t+1}} = \frac{\phi}{(1-\xi)p_{t+1}} \tag{3}$$

Following Getachew and Turnovsky (2015), we assume output in each sector is produced by the production functions specified in equations (4) and (5), in

[9] We make the assumption that consumption only takes place when individuals are old. In that case, all income earned by the young is saved. This assumption generates results that are very similar to more general models where utility is derived from consumption in both periods of life, preferences are homothetic, and, as a result, savings are a constant fraction of income. With our assumption, the savings rate happens to be constant at 100%.

[10] We assume that $w_{a,t}$ is inclusive of the relative price, p_t, as shown in equation (10).

which private capital and public capital are combined in accordance with the CES production function, with elasticity of substitution being $\epsilon = 1/(1-\rho)$:

$$Y_{a,t} = A_{a,t}[a_1 K_{at}^{\rho_a} + (1-a_1)G_a^{\rho_a}]^{\theta_a/\rho_a} L_{at}^{1-\theta_a} \qquad 0 < a_1 < 1 \tag{4}$$

$$Y_{m,t} = A_{m,t}[a_2 K_{mt}^{\rho_m} + (1-a_2)G_{mt}^{\rho_m}]^{\theta_m/\rho_m} L_{mt}^{1-\theta_m} - \gamma L_{m,t} \qquad 0 < a_2 < 1 \tag{5}$$

$$Y_t = Y_{a,t} p_t + Y_{m,t} \tag{6}$$

Here, $A_{a,t}$ and $A_{m,t}$ are total factor productivity (TFP) in the agriculture and modern sectors, respectively. $K_{a,t}$ and $K_{m,t}$ are the total amount of physical capital used in each sector, respectively, and $L_{a,t}$ and $L_{m,t}$ stand for the total amount of labor employed in each of the two sectors. $G_{a,t}$ and $G_{m,t}$ denote the stock of public capital in the agriculture and modern sectors, respectively. γL_{mt} represents the labor friction in the modern sector: we subtract a term that increases proportionately with the size of labor employed in the modern sector. We think of this loss occurring because of bureaucratic problems related to a large labor force in the modern sector. This specification follows Das and Saha (2015).

We assume that investments in public infrastructure can be financed by a tax on (i) labor income in the modern sector, (ii) labor income in the agriculture sector, or (iii) both. In addition to financing the public good investment, the government also subsidizes consumption of agricultural products. The government budget constraint can be written as

$$G_{a,t} + G_{m,t} + \xi p_t c_{a,t} = \tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} \tag{7}$$

where ξ is the subsidy for the consumption of the agriculture good. We do not allow public debt in our model. Letting $\delta_a \in [0, 1]$ denote the fraction of government revenue allocated to agricultural infrastructure, we can write

$$G_{a,t} = \delta_a[\tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} - \xi p_t c_{a,t}] \tag{8}$$

$$G_{m,t} = (1-\delta_a)[\tau_a w_{a,t} L_{a,t} + \tau_m w_{m,t} L_{m,t} - \xi p_t c_{a,t}] \tag{9}$$

The returns to factors in the two sectors are

$$w_{a,t} = p_t A_{at}[a_1 K_{at}^{\rho_a} + (1-a_1)G_{at}^{\rho_a}]^{\theta_a/\rho_a}(1-\theta_a)L_{at}^{-\theta_a} \tag{10}$$

$$w_{m,t} = A_{at}[a_2 K_{mt}^{\rho_m} + (1-a_2)G_{mt}^{\rho_m}]^{\theta_m/\rho_m}(1-\theta_m)L_{mt}^{-\theta_m} - \gamma \tag{11}$$

$$r_{a,t} = p_t A_{at}\theta_a[a_1 K_{at}^{\rho_a} + (1-a_1) * G_{at}^{\rho_a})^{\theta_a/\rho_a - 1} a_1 K_{at}^{\rho_a - 1} L_{at}^{1-\theta_a} \tag{12}$$

$$r_{m,t} = A_{at}\theta_m[a_2 K_{mt}^{\rho_m} + (1-a_2) * G_{mt}^{\rho_m})^{\theta_m/\rho_m - 1} a_2 K_{mt}^{\rho_m - 1} L_{mt}^{1-\theta_m} \tag{13}$$

Assuming costless mobility of labor, we can equate the after tax wage rates across the two sectors

$$(1 - \tau_a)w_{a,t} = w_{m,t}(1 - \tau_m) \tag{14}$$

Similarly, we also assume perfect capital mobility, which implies

$$r_{a,t} = r_{m,t} = r_t \tag{15}$$

For capital and labor markets, the aggregate capital K_t and aggregate labor L_t are both known at the beginning of time t:

$$\begin{aligned} K_{at} + K_{mt} &= K_t \\ L_{at} + L_{mt} &= L_t \end{aligned} \tag{16}$$

There is no population growth in the model: $L_t = L_{t+1}$. All income is saved and funds the future capital stock:

$$K_{t+1} = (1 - \tau_a)p_t w_{a,t} L_{a,t} + (1 - \tau_m) w_{m,t} L_{m,t}$$

For the two goods market, agriculture goods can only be used for consumption. Modern sector goods can be used as consumption or investment (see, for example, Cheremukhin et al. 2014). The market clearing condition for the two goods are

$$\begin{aligned} c_{at} L_t &= Y_{at} \\ c_{mt} L_t + K_{t+1} - (1 - d)K_t + G_{t+1} &= Y_{mt} \end{aligned} \tag{17}$$

Finally, both sectors have no direct interaction with one another, the economy is closed, and prices are determined fully by domestic production.

III. Calibration Parameters

This section describes the parameters used in our calibration exercises. Our calibration strategy is to match the initial shares of sectoral employment rates, sectoral capital–output ratios, and sectoral GDP ratios; and the rate of decline (increase) of these shares over a 30-year period, as depicted in Table 1.

The initial TFP in the agriculture sector (A_a) is set at 2, while that in the modern sector (A_m) is set at 1. The growth rate of agricultural TFP is 1.4, equivalent to 1.4% annual growth; the growth rate of modern TFP is 1.3, equivalent to 1.3% annual growth. This reflects that average annual TFP growth was lower in the modern sector in India in its earlier stages of development (Verma 2012). In the agriculture production function, a_1 represents the weight of private capital when combined with public capital, and is set at 0.8. Similarly, a_2 is also set at 0.8. This reflects the common observation that private capital is more important than public capital in final goods production. The CES parameters, ρ_a and ρ_m, each assume two values: 0.6 and -0.3. If $\rho = 0.6$, then private capital and public capital are substitutes; if $\rho = -0.3$, then private and public capital are complements. In the production function, labor has a power parameter $(1 - \theta)$. The crucial distinction in our model between the two sectors is capital intensity. In all the experiments below, we assume that the modern sector is more capital intensive than the agriculture sector: $\theta_m = 0.5 > \theta_a = 0.3$.

We now describe the policy parameters. The government funding share for agricultural infrastructure, δ_a, is set at 0.5 in the baseline model and assumes values from 0.2 to 0.55 in the experiment. The tax rate of agricultural income, τ_a, is 0.2 in the baseline and varies from 0.1 to 0.4 in the experiment. Similarly, the tax rate on modern sector income, τ_m, is 0.3 in the baseline, and varies from 0.1 to 0.4 in the experiment. Government subsidies of agriculture goods prices, ξ, are set at 0.1 in the baseline and range from 0.01 to 0.15 in the experiment. Lastly, the labor friction parameter, γ, is set at zero in the baseline, and varies from zero to 0.1 in the experiment. These values are summarized in Table 2.

IV. Policy Experiments

Figure 4 depicts our calibration to Indian data, assuming no labor market frictions and no subsidies. We refer to this as the baseline model. The dashed lines show the results for the complementarity assumption.[11] We assume that public capital is split evenly between the two sectors. For the calibrated version with the parameter values from Table 2, we obtain the following results. First, GDP per capita grows persistently, as shown in Figure 3. Second, consistent with the observations in Table 1, the agriculture sector is shrinking over time: its employment share drops from 67% to 40%. The decline in agriculture's share of GDP is even larger proportionately, dropping from 56% to 30%. These declines are largely consistent with the asymmetry in the data in Table 1, which show that agriculture's share of GDP falls more rapidly than its employment share. The sizes of these relative drops are maintained if public and private capital are substitutes, rather than complements. The reason why overall GDP is lower when public and private capital are complements is that a limited amount of G constrains total output as this constrains the productivity of K. As a result, overall output is less than the case where K and G are substitutes.[12]

[11] In each experiment, we show two technological cases: (i) the case of private capital and public capital being complements, which we take to be the empirically valid assumption, and (ii) the case where they are substitutes.

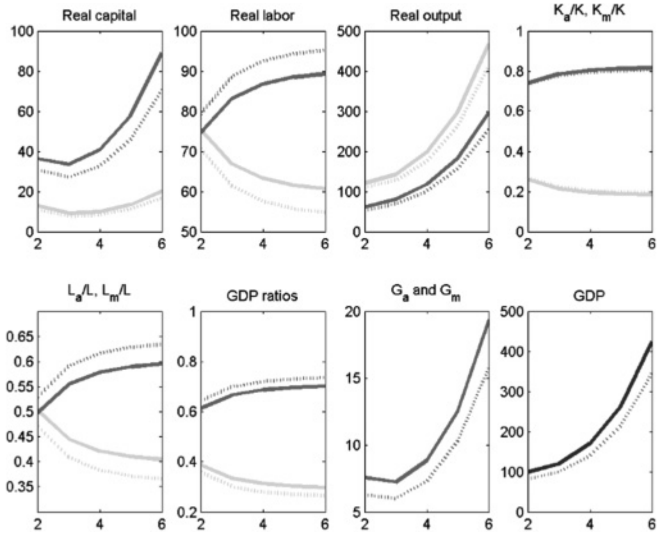
[12] An example of substitutes is government-owned machinery versus privately owned machinery. An example of complements is private factories that rely on public infrastructure to deliver products.

Table 2. **Calibration Parameters**

Parameter	Definition	Baseline Value	Experiments				
ϕ	Parameter in Utility	1					
A_a	Initial TFP in Agriculture	2					
A_m	Initial TFP in Manufacturing	1					
g_a	Growth Rate of Agricultural TFP (20 years)	1.4					
g_m	Growth Rate of Manufacturing TFP (20 years)	1.3					
a_1	Capital Parameter in Agriculture Production	.8					
a_2	Capital Parameter in Manufacturing Production	.8					
ρ_a	CES Parameter in Agriculture Production	.6, −.3					
ρ_m	CES Parameter in Manufacturing Production	.6, −.3					
θ_a	Parameter in Agriculture Production	.3					
θ_m	Parameter in Manufacturing Production	.5					
Fiscal Policy							
δ_a	Government Infrastructure Share in Agriculture	.5	{0.2, .55}				
τ_a	Tax Rate on Agriculture Income	.2		{0.1, 0.4}			
τ_m	Tax Rate on Manufacturing Income	.3			{0.1, 0.4}		
ξ	Government Subsidy on Agriculture Prices	.1				{0.01, 0.15}	
Labor Market							
γ	Labor Market Friction	0					{0, 0.1}

CES = constant elasticity of substitution, TFP = total factor productivity.
Source: Authors' calculations.

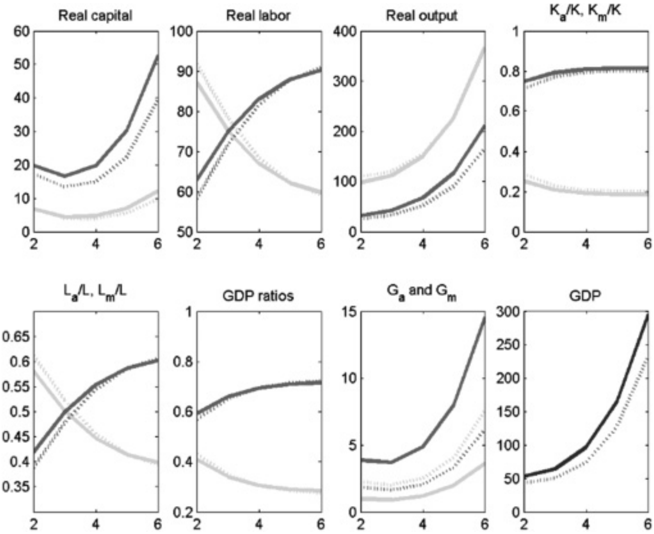
Figure 4. **Baseline Model: No Labor Market Frictions, No Subsidies**



GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

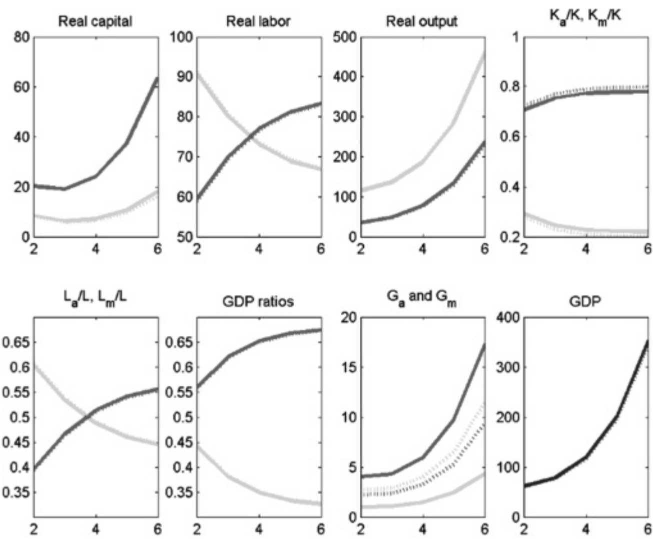
One important policy issue that can fundamentally influence the growth potential relates to how public capital should be allocated between the agriculture and modern sectors. It is expected that increasing the share of public capital going to agriculture will increase agricultural output, the question is by how much. In the first policy experiment (Figure 5), we increase agriculture's share of infrastructure, δ_a, from 0.2 to 0.6. This represents a very significant policy reform. An immediate impact of an increase in the share of infrastructure in agriculture is that G_a increases and G_m falls. Because G and K are assumed to be complements, K_m also falls. Figure 6 reveals that GDP growth declines as more public capital is allocated to agriculture. This is true simply because of the higher capital intensity (private and public) of the modern sector relative to agriculture. As expected (because L_a also increases), the relative size of the agriculture sector increases, both measured in terms of employment and GDP share, although the effect on the labor share seems to be larger than on the GDP share. The effect on the level of overall GDP is persistent, while the magnitude of the effects on agriculture's labor share and GDP share declines over time. Finally, the effect on overall GDP is far smaller when public and private capital are substitutes. This makes sense; when public and private capital are substitutes, an increase (decrease) in public capital is followed by a decrease (increase) in private capital, thus undoing the effect of policy change. In the case of complements, a reinforcing effect occurs that magnifies the policy effect.

Figure 5. **Policy Experiment: Increase δ_a from 0.2 to 0.6; *K* and *G* complements**



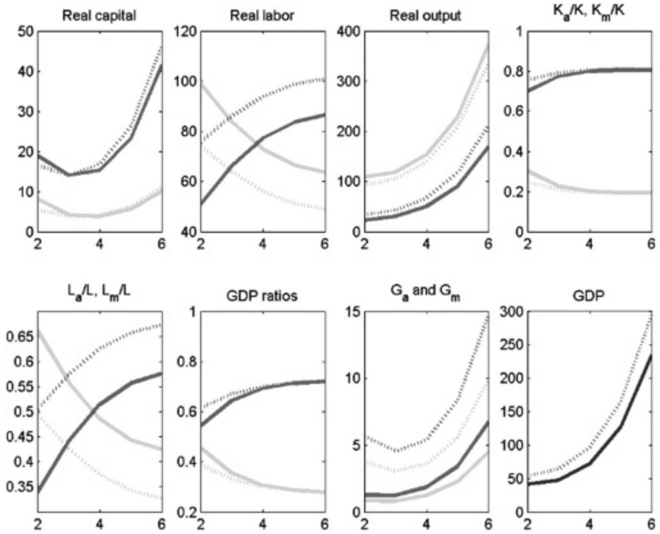
GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

Figure 6. **Policy Experiment: Increase δ_a from 0.2 to 0.6; *K* and *G* substitutes**



GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source:Authors' calculations.

Figure 7. **Policy Experiment: Increase τ_a from 0.1 to 0.4; increase government expenditure proportionately in both sectors; *K* and *G* complements**

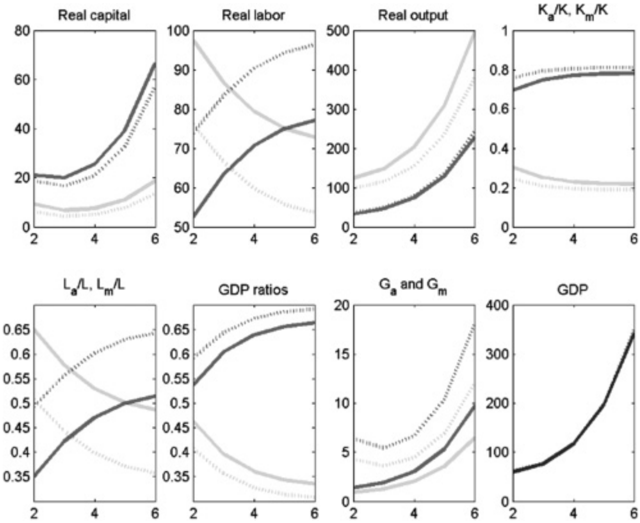


GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

In the next policy experiment, we increase the agricultural income tax rate, τ_a, from 10% to 40% and use the extra tax revenue to fund increased investment (proportionately) in both types of infrastructure. We first consider the case of complements (Figure 7). This policy leads to a large and persistent increase in GDP for two reasons. First, the tax increase in the agriculture sector induces a large shift of labor (because of the reduction in the after-tax wage) out of agriculture and into the more capital-intensive modern sector. Second, the increased stock of infrastructure in both sectors increases output directly, as well as indirectly through the productivity of capital (an augmentable factor) and labor. Of course, the last effect is not there, or is at least smaller, when public and private capital are substitutes (Figure 8). The massive shift of labor from agriculture to the modern sector increases output in the modern sector and decreases output in agriculture. But the associated change in agriculture's share of GDP is relatively small and declines over time.

Alternatively to financing additional investment in public infrastructure, the government could raise taxes on income, τ_m, in the modern sector instead. In Figure 9, we illustrate the economic effects of raising the income tax in the modern sector from 10% to 40% (an identical increase compared to τ_a in the previous case) and use the extra revenue to finance infrastructure investment proportionately in both sectors. Once again, an immediate impact of an increase in τ_m is that G_a and G_m

Figure 8. **Policy Experiment: Increase τ_a from 0.1 to 0.4; increase government expenditure proportionately in both sectors; *K* and *G* substitutes**

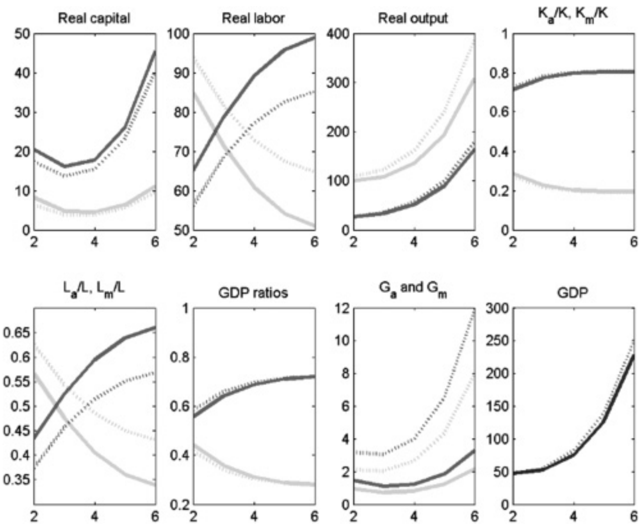


GDP = gross domestic product.

Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.

Source: Authors' calculations.

Figure 9. **Policy Experiment: Increase τ_m from 0.1 to 0.4; increase government expenditure proportionately in both sectors; *K* and *G* complements**

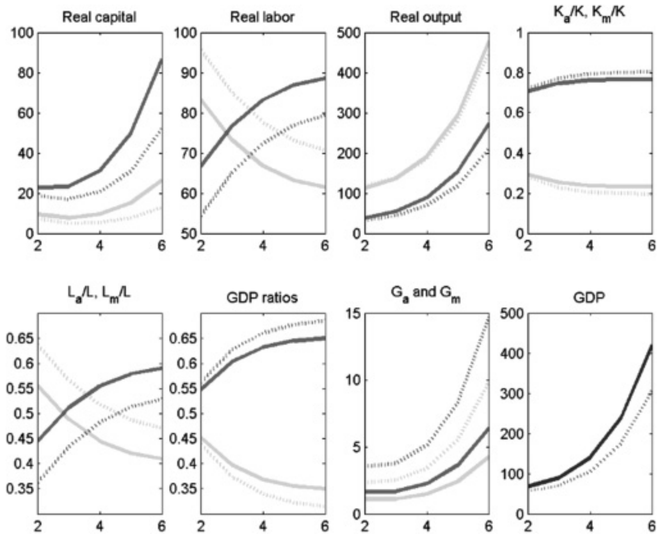


GDP = gross domestic product.

Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.

Source: Authors' calculations.

Figure 10. **Policy Experiment: Increase τ_m from 0.1 to 0.4; increase government expenditure proportionately in both sectors; *K* and *G* substitutes**



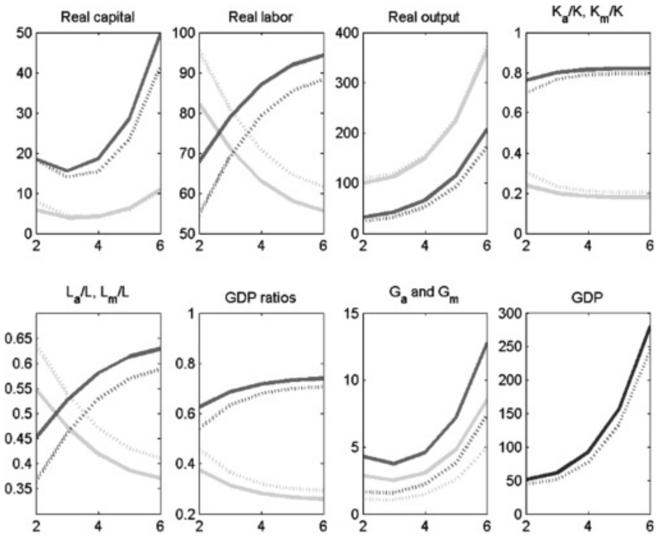
GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

increase. However, there is one basic benefit and one basic cost associated with this policy. The cost is a shift of labor to agriculture with its lower capital productivity. The benefit is the extra infrastructure capital. Therefore, when public and private capital are complements, these two effects roughly cancel each other out and, as a consequence, the effects on overall GDP are small; when public and private capital are substitutes, the effect on overall GDP is negative. The substitutability induces larger shifts in labor across the sectors, which translates into a larger decline in modern sector output, which in turn causes a larger decline in overall GDP. These results also show that funding more infrastructure investments in both sectors by raising labor income taxes in the agriculture sector raises potential growth.

Many poor economies maintain subsidies for agricultural products, such as food, and India is no exception in this regard. In Figure 11, we illustrate the effect of increasing such a subsidy. As expected, we find that a higher subsidy, or an increase in ξ, leads to a reduction in G_a and G_m. We also find that (i) the subsidy for the agriculture good shifts demand away from the modern sector to the agriculture sector, and (ii) this shift drags down potential growth and decreases overall GDP.

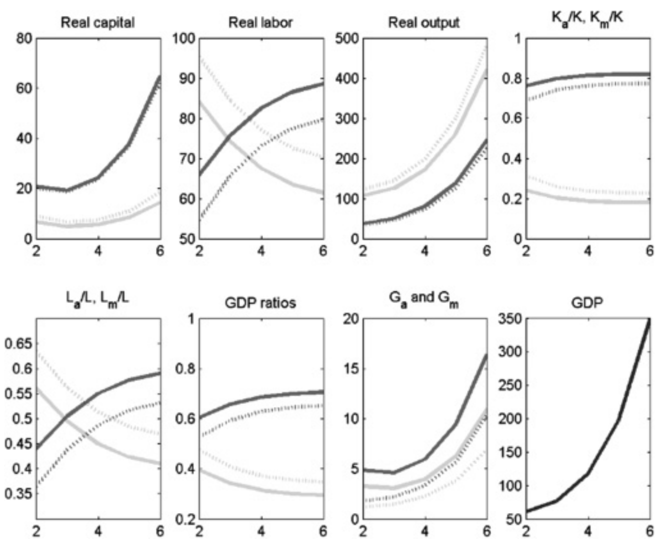
There are many reasons to believe that various regulations and labor practices in manufacturing and the service sector (modern sector) hold back productivity at unnecessarily low levels. We model this in the production function as a subtraction from output by the amount, γL_m. So far, we have assumed in all computations

Figure 11. **Policy Experiment: Increase ξ from 0.01 to 0.15; *K* and *G* complements**



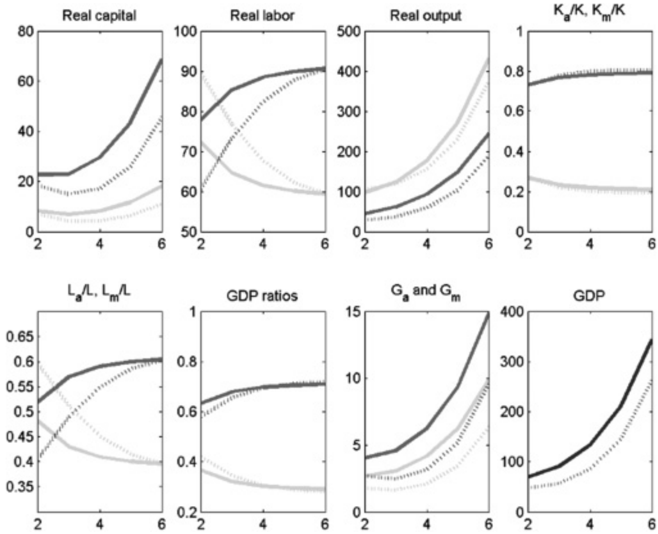
GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

Figure 12. **Policy Experiment: Increase ξ from 0.01 to 0.15; *K* and *G* substitutes**



GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

Figure 13. **Policy Experiment: Increase γ from 0.0 to 0.1; *K* and *G* complements**



GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

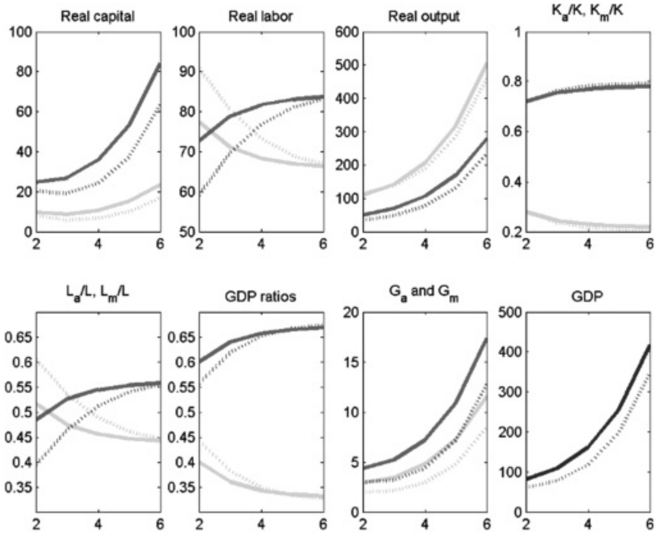
that this drag is zero. To investigate the effect of this regulatory drag on economic growth, we increase γ in equation (5) from zero to 0.1. Figure 13 shows that increasing the regulatory drag decreases wages in the modern sector, shifting employment to agriculture. Because γ increases, modern sector GDP, Y_m, also falls, which leads to a reduction in G_a and G_m. This is a new interpretation of the effect of labor market frictions on sectoral infrastructure investments. Labor market frictions are typically seen to employ inefficient labor in the modern sector (see, for example, Gupta and Kumar 2012) or constrain growth by deterring entry and skewing firm-size distribution (see, for example, Alfaro and Chari 2014). In our model, labor market frictions depress potential output by pulling productive resources out of the modern sector.

We also find that there is a drop in output in both the modern and agriculture sectors, with the drop in the modern sector being larger. Since both sectoral outputs decline, overall GDP declines as well. These results are very similar when public and private capital are substitutes.

A. Robustness

A feature of our model described in equations (1)–(17) is that the relative price of the agriculture good falls steadily. The drop in price is a function of the Cobb–Douglas specification, which has been used in many similar models. In effect,

Figure 14. **Policy Experiment: Increase γ from 0.0 to 0.1; K and G substitutes**



GDP = gross domestic product.
Notes: Solid lines denote the period before the policy experiment; dashed lines denote the period after the policy experiment. Medium-shaded lines denote the modern sector; light-shaded lines denote the agriculture sector; dark-shaded lines denote overall GDP.
Source: Authors' calculations.

as the TFP of the agriculture sector increases, the price of the agriculture product decreases. This offsets the increase in the agricultural product, $Y_{a,t}$. To adjust for this, instead of equation (6) we define output in constant prices, which holds the agriculture price from the first period fixed:

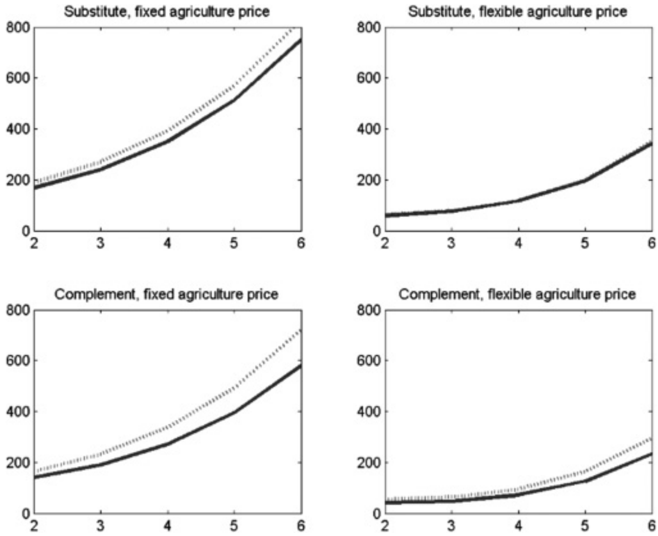
$$Y_t = p_0 Y_{a,t} + Y_{m,t} \tag{18}$$

p_0 is endogenously determined from the system. In subsequent periods, it is kept fixed.[13] We consider one key policy experiment: an increase in agriculture income taxation. In the first period, zero, Figure 15 shows that the overall GDP level defined by equation (18) is higher than the corresponding level of GDP from equation (6). Under the fixed-price definition of GDP, the relative price of the agriculture good is invariant with respect to changes in agricultural productivity. When the relative price is flexible, it declines over time.[14]

[13]Because of parameter sensitivity, in the fixed-price definition of GDP, we change the following parameter values in Table 2: (i) initial agricultural TFP, A_a, is set to 3; (ii) initial manufacturing TFP, A_m, is set to 1; (iii) agricultural TFP growth is set to 1.3%; and (iv) manufacturing TFP growth is set to 1.2%. To facilitate the GDP comparison, we apply this subset of parameters for the calculation of flexible-price GDP as well.

[14]The comparisons between flexible-price and fixed-price GDP for the other policy experiments are available from the authors upon request. In these, we see that the ordering of the policies that we consider by their effects on growth are invariant to the definition we use.

Figure 15. **Comparison between fixed-price GDP from equation (18) (dark-shaded line) and flexible-price GDP from equation (6) (dashed medium-shaded line) after τ_a increases from 0.1 to 0.4**



GDP = gross domestic product.
Notes: Graphs in top row correspond to K and G being substitutes; graphs in bottom row correspond to K and G being complements.
Source: Authors' calculations.

V. Conclusion and Policy Implications

We build a two-sector (agriculture and modern) OLG growth model calibrated to India to examine the effects of sectoral tax policies, sectoral infrastructure investments, and labor market frictions on the sectoral allocation of labor and capital in the Indian economy. Our paper hopes to address two broad issues. First, how do sectoral tax rates and labor market frictions prevent developing economies like India from realizing their growth potential? Second, what prevents the development and expansion of the modern sector in a growing economy like India? These questions have policy implications as distortions in the agriculture and modern sectors have constrained growth in India by limiting the full productivity effect of factor reallocation.

The calibrated model yields several policy implications. We show that a major policy reform that increases the sectoral allocation of public capital to the agriculture sector leads to a smaller effect on overall GDP when public and private capital are substitutes rather than complements. When public and private capital are substitutes, an increase (decrease) in public capital is followed by a decrease (increase) in private capital, thus undoing the effect of the policy change. In the case of complements, a reinforcing effect takes place that magnifies the policy effect. We also show that funding more infrastructure investment in both sectors by raising labor income taxes in the agriculture sector raises potential growth. If the same policy reform is enacted by taxing labor income in the modern sector, potential growth increases by much less.

Finally, increasing the regulatory drag—or labor market friction—decreases wages in the modern sector and shifts employment to agriculture. This leads to a drop in output in both the modern and agriculture sector, with the drop in the modern sector being larger. Since both sectoral outputs decline, overall GDP declines as well. These results are very similar when public and private capital are substitutes.

In sum, policy reforms relating to sectoral tax rates, sectoral infrastructure investments, and labor market frictions can have a sizable effect on growth and potential growth in the Indian context.

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