Investing Like China

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Abstract

There are several facts that we document about the Chinese economy during the last decade in this paper: i) The skill premium in wage has been rising till 2008 but falls afterwards; ii) the aggregate investment rate in China increases from 42% in 2008 to 47% in 2013, among which structure investment contributes most of the surge; iii) on the firm level, the return to capital is lower for the firms with lower averaging schooling year. This paper attempts to explain the above features of the capital and labor markets in the Chinese economy using a two-sector model. Our model shows that these facts that exist in Chinese capital and labor market are likely to be caused by the distortion in the government investment, which is modeled as government's subsidizing the infrastructure sector by offering a lower loan rate, and related structural change. Given that the infrastructure sector can absorb capital with low rate, large amount of investment flows into this sector, which also drives up the demand for unskilled labor. The rising demand for unskilled labor leads to an increase of unskilled wage. On the other hand, since infrastructure sector can borrow at a low rate, it has the incentive to borrow a lot, thus pushing up the market interest rate for the general good sector. The resulting reduction of investment in the general good sector reduces the demand for skilled labor and hence the growth of skilled labor wage, leading to a fall in the skill premium in wage. The model is calibrated to match the Chinese data. Our results suggest that the government has strong incentive to invest in the infrastructure sector if they are only interested in the short-run output level. This also helps to explain the high local government debt during recent years, as the local government has strong incentive to invest in the infrastructure sector, they borrow more. We also find that the more government deviates from the non-distortionary rate, the larger the welfare loss. More interestingly, when there exists abundant unskilled labor due to frictions to migration from the rural area, distortionary government investment could in fact increase the marginal product of labor and help overcome the frictions, and hence increase welfare. However, once rural to urban migration is completed, there is only welfare loss associated with distortionary government investment.

JEL Codes: E25, O16, O41, O53, P23.

Keywords: Credit Market Imperfections; Economic Growth; Transition; Migration; Abundant Unskilled Labor Supply; Wage Premium.

1 Introduction

There are several facts that we document about the Chinese economy during the last decade in this paper: i) The skill premium in wage has been rising till 2008 but falls afterwards; ii) the aggregate investment rate in China increases from 42% in 2008 to 47% in 2013, among which structure investment contributes most of the surge; iii) on the firm level, the return to capital is lower for the firms with lower averaging schooling year. This paper attempts to explain the above features of the capital and labor markets in the Chinese economy using a two-sector model.

Several interesting patterns in Chinese factor markets are observed in recent years. On the labor market, there is a significant shrinking of the skill premium in wages after 2008. From 2009 to 2013, the college premium falls from 0.474 to 0.393. If we look at the sectoral level, between 2008 and 2012, the average wage in the construction sector, where the average school years of the labor force is about 9, went up by 72%, while the average wage in the IT sector, where the average school years of the labor force is about 13, grew by only 47%. On the capital market, from 2008 to 2013, the investment rate has increased from 42% to 47%. Among aggregate investment, after 2008, structure investment becomes the main driving force behind the surge of aggregate investment. We show that the structure investment climbes from around 2.6 times equipment investment from 2008 all the way up to 3.3 times till 2013. The relationship between the skill intensity of a sector and its averge return to capital has also changed after 2008. On the firm level, in 2007 and 2008, the lower the skill intensity, the higher return to asset of a firm. However, in 2009 and 2010, the skill intensity and the return to asset shows positive relationship.

We believe the stimulas plan implemented at the end of 2008 is responsible for above interesting patterns. Under such a plan, the firms in infrastructure sector obtain more access to cheap credit, and structure investment surges after 2009. The return to capital for such type of investment falls as the result. Moreover, nn the capital market, infrasturcture investment crowds out the capital demand and push up the market loan rates for other firms. On the labor market, since infrastructure sector uses unskilled labor intensively, the relative demand for unskilled labor increases, which leads to decreasing skill premium. In general, firms with lower skill intensity are more likely to get cheap credits after 2009, and thus have lower average return to asset. All these results are consistent with above observations.

We built a two-sector growth model to show how these features of Chinese capital and labor market can be generated from the distortion in the government investment and related structural

change. In particular, we assume that the economy has two production sectors, an infrastructure sector and a general good sector. Goods from the two sectors are combined into final good for consumption and investment. The infrastructure sector uses unskilled labor and capital for production while the general good sector uses skilled labor, unskilled labor and capital. There is a banking sector which takes deposits from the household, lends part of it to the infrastructure sector with government subsidized lower rate and lends the rest to the general goods sector with the market rate. Bank makes zero profit.

Given that the infrastructure sector can absorb capital with a lower rate, they invest and at the same time hire. The rising demand for the unskilled labor drives up the unskilled wage. On the other hand, the expanding infrastructure sector crowds out the demand from the other sector, hence demand for skilled labor also declines and the skilled labor wage falls, leading to a fall in the wage premium. Since infrastructure sector can borrow at a low rate, it has the incentive to borrow a lot, thus driving up the market rate for the general good sector.

The model is calibrated to match the Chinese data and simulation results show that if the government starts with a non-distortionary interest rate and gradually increases the interest rate subsidies, the model predicts that the wage premium falls, market interest rate rises, infrastructure sector expands and general good sector shrinks, which are all in line with data observations. More interestingly, aggregate output increases first but falls soon after the boom while consumption falls from the beginning, which suggests that if they are only interested in the short-run output level, the government has strong incentive to invest in the infrastructure sector. We also find that the more the government deviates from the non-distortionary rate, the larger the welfare loss.

The welfare implication could be different under couple of extensions of the model. First, we incorporate rural migration. When there are abundant unskilled labor, for example immigration from the rural area, distortionary government investment could in fact increase the marginal product of labor, and hence increase the welfare. However, once immigration is finished, the previous analysis holds and welfare loss is incurred. Second, we can treat infrastructure good as public good. Given that better infrastructure has positive externality, potentially increase TFP in other sectors, government subsidized infrastructure investment could enhance the overall social welfare

Our results also indicate that the expansion of college enrollment may not be the main driving force behind the falling college wage premium. If the supply of skilled labor increases, then we should see the expansion of skilled labor intensive sectors. However, the data shows exactly the opposite, which is better explained by our demand side story: demand of skilled labor is low due

to capital market distortions, so wage premium declines and skilled labor intensive sectors grow slower.

Our paper is related to recent literature that investigates the overall impact of misallocation of factors on the economy. Some studies in this literature, such as Gollin et al. (2004), Restuccia et al. (2008), Vollrath (2009) and Song et al. (2011), explore the issue along sectoral dimension, while Alfaro et al. (2008), Banerjee and Duflo (2008), Guner et al. (2008), Restuccia and Rogerson (2008), Bartelsman et al. (2009) and Hsieh and Klenow (2009) focus on the misallocation across firms within a sector. In particular, Adamopoulos and Restuccia (2011) examine the impact of misallocation across production units within agriculture on misallocation between the agricultural and non-agricultural sector. Song et al. (2011) emphasize the wedges in the returns to capital between the state and the non-state sectors. Hsieh and Klenow (2009) investigate the impact of factor misallocation across firms within four-digit manufacturing industries on aggregate TFP in China and India, using an approach proposed by Restuccia and Rogerson (2008). They found that a more efficient factor allocation contributed to around 2 percent a year aggregate TFP growth in China's manufacturing sector between 1998 and 2005. Brandt et al. (2013) follow Hsieh and Klenow's method, but examine factor misallocation and its impact on TFP at a more aggregate level, between provinces and between the state and the non-state sectors in China's non-agricultural economy.

In this paper, we also focus the impact of distortions on Chinese economy. But unlike most studies in the literature, we are not trying to quantify the distortions or its welfare loss. Instead, we explore the linkage between distortions in capital market and labor market, and study its macro implications on Chinese economy. We believe it's a new dimension of the research, and our studies will contribute to the literature along this line.

Note that there are a few papers exploring the linkage between wage inequality and new capital goods. For instance, Goldin and Katz (1998) report that industries that used electricity tended to favor the use of skilled labor. Autor, Katz, and Krueger (1998) find that the spread of computers may explain the growth in the demand for skilled workers since the 1970s. Flug and Hercowitz (2000) discover that an increase in equipment investment leads to a rise both in the demand for skilled labor and in the skill premium. In a similar vein, Caselli (1999) documents that there has been a strong, positive relationship between changes in an industry's capital-labor ratio and changes in its wages. Greenwood and Yorukoglu (1997) argue that investment-specific technological progress contributes to rising skill premium.

Our project is closely related to above literature in the sense that we also emphasize the role of demand side on the wage inequality. But we differ from these studies by focusing on the crowding-out effect of capital misallocation on labor the demand of skilled labor. Our results suggest that higher investment may lead to lower skilled premium, which is in sharp contrast to the literature that suggesting rising skill premium.

The paper is organized as follows. In Section 2, we show the stylized facts in China. In Section 3, we describe the model economy, highlight the key mechanism and present the main results. In Section 4, we discuss the extension of the model. In Section 5, we discuss important implications and provide several robustness checks. Section 6 concludes.

2   Empirical Evidence

China has maintained close to 10% annual growth rate over the last thirty years, which still remains a miracle to many researchers as well as policy makers. In this section, we present a set of empirical facts during China's rapid growth period. We document the dynamics of multi-sector growth pattern, the wage premium, aggregate investment rate and its components, return to capital to different sectors and migration of unskilled worker to urban area. The aim is to provide a set of stylized facts that capture the unique features of chinese economy. These facts will be the basis of the theoretical discussion in the subsequent sections of the paper.

2.1   Skill premium in wage

The economic transition in China has been accompanied by increasing income inequality, especially the wage inequality between skilled labor and unskilled labor. Follow Ge and Yang (2014), we use UHS data to compute the skill premium. Our results are reported in Figure 1, which shows the trend of skill premium since 2000.[1] We see a large increase in the skill premium after China's entrance into the WTO which is also widely documented in the literature. However, the trend reverts in 2009. Starting from 2009, skill premium seems to be declining rapidly from 0.474 to 0.393 as can be seen in Figure 1.

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[1]Here the skilled labor includes high school and college education. We also compute the case when skilled labor only includes college education. The results are pretty much the same.
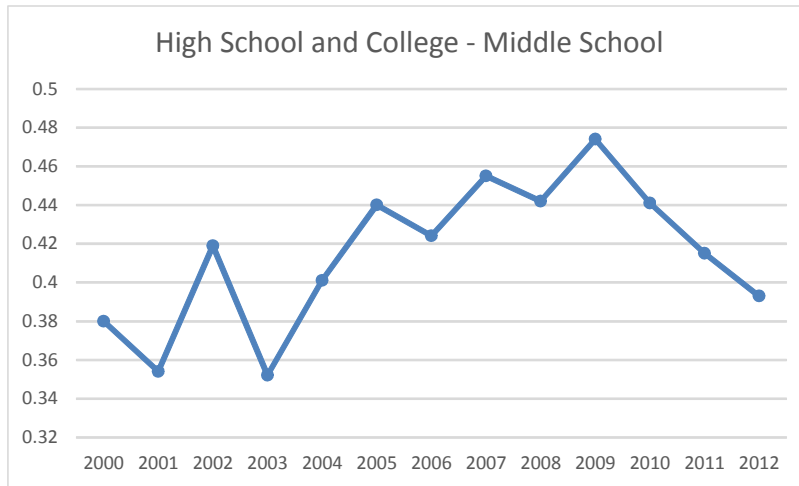
Figure1 Source: UHS survey data

2.2 Infrastructure Investment

The aggregate investment rate in China remains high and keeps increasing during recent years. Figure 2 shows that till 2013, the aggregate investment rate has achieved as high as 47%.
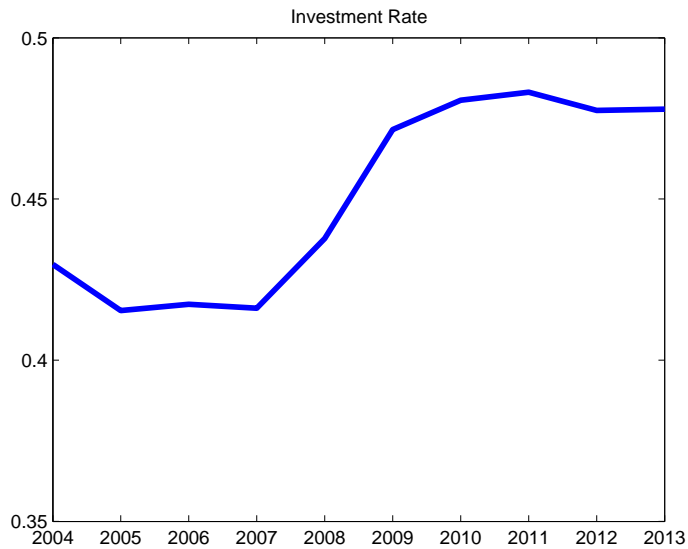

Figure 2   Source: China Statistical Yearbook, 2013

Among aggregate investment, after 2008, structure investment becomes the main driving force behind the surge of aggregate investment. In Figure 3, we show that the structure investment climbes from around 2.6 times equipment investment from 2008 all the way up to 3.3 times till
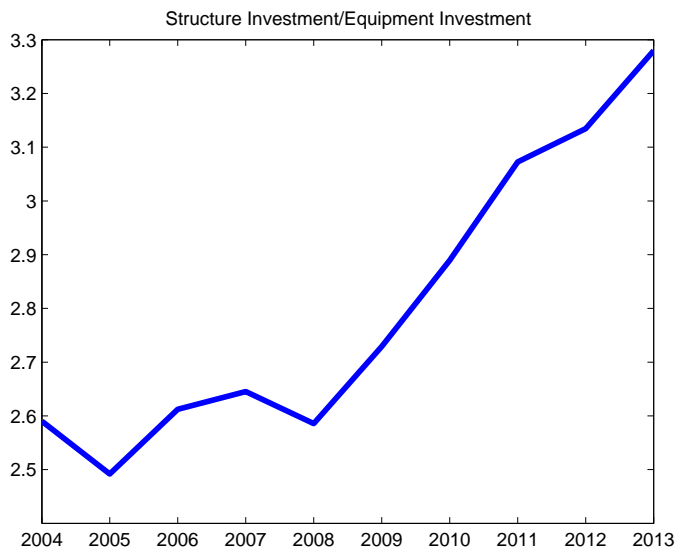
2013.

Figure 4   Source: China Statistical Yearbook

Although China is known to have a housing bubble from 2008, surprisingly, the data shows that non-residential structure increase is the main driving force behind the total structure investment. Figure 5 shows the share of non-residential investment to total structure investment. We observe a 10% increase from 2007 to 2013.
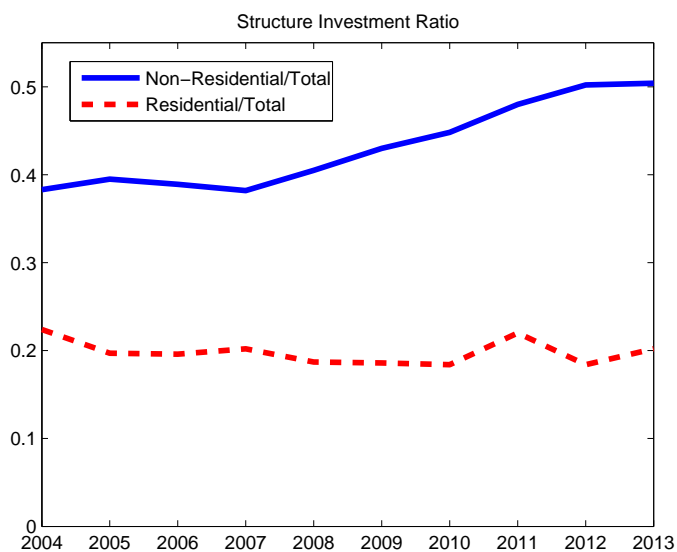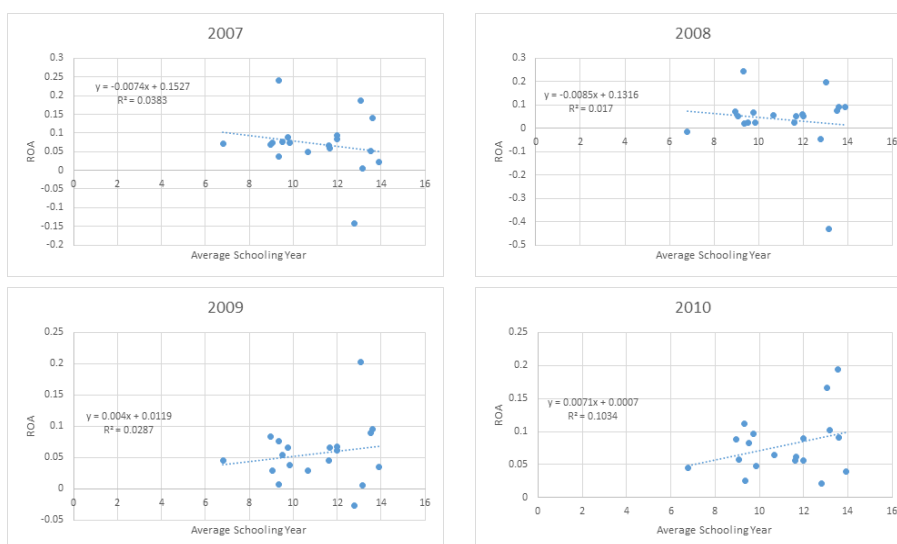

Figure 5   Source: National Bureau of Statistics

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2.3   Skill Intensity and Return to Capital

The relationship between the skill intensity of a sector and its averge return to capital has also changed after 2008. As shown in Figure 5, in 2007 and 2008, the lower the skill intensity, the higher return to asset. However, in 2009 and 2010, the skill intensity and the return to asset shows positive relationship. The intuition behind this fact is that from 2009, because of China's government's stimulus package, most of the infrastructure projects receive government funding at very low cost. Because they face low cost of capital, they will invest so much that the marginal return to capital is low. If we assume that the average return to capital is positively correlated with the marginal return to capital, then infrastructure projects should generally yield low return to assets. This is exactly what we observe in Figure 5.

Source: National Bureau of Statistics

We document this pattern more rigorously by using firm level tax data from 2007 to 2010 covering around 500, 000 firms each year. In column 1 of Table 1, we report the results of a regression of return to asset on the average schooling year , where we control for ownership, market concentration, firm size, region and time. The estimated coefficients for 2009 and 2010 are much larger than those of 2007 and 2008. In column 2, we use a different measure of return to asset and the results remain robust[2]. Another interesting fact that is in line with the literature is that the state-owned

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[2]

- R1 = (Operating Profit + Financial Expenses – net Value-Added Tax – net Vehicle and Vessel Tax) / (net Fixed Assets + Ending Inventory)

- R2 = (Operating Profit + Non-operating Income – Subsidies – Non-operating Expenses + Donation + Financial Expenses – net Value-Added Tax – net Vehicle and Vessel Tax) / (net Fixed Assets + Ending Inventory)

enterprises have lower return to capital, indicating a subsidy that the SOEs receive.

Consider the growth rate of a firm and its average schooling year across time, column 3 shows that the firm grows faster when the average schooling year is low in 2009 and 2010. However, we don't observe this phenomenon pre-2009.

Dependent variables	Return to Capital		Value-Added Growth
	(1)	(2)	(3)
$\text{ASY}_{t=2007}$	0.001***	0.000***	
	(0.0000302)	(0.0000798)	
$\text{ASY}_{t=2008}$	0.008***	0.007***	0.229***
	(0.0000258)	(0.0000681)	(0.0001981)
$\text{ASY}_{t=2009}$	**0.037*****	**0.038*****	**−0.065*****
	(0.0000204)	(0.0000539)	(0.0001653)
$\text{ASY}_{t=2010}$	**0.064*****	**0.065*****	**−0.234*****
	(0.0000168)	(0.0000442)	(0.0001498)
POE dummy$_{t=2007}$	0.029***	0.045***	
	(0.000094)	(0.0002479)	
POE dummy$_{t=2008}$	0.079***	0.075***	0.522***
	(0.0000831)	(0.0002192)	(0.0006625)
POE dummy$_{t=2009}$	0.090***	0.084***	0.047***
	(0.0000693)	(0.0001827)	(0.0005514)
POE dummy$_{t=2010}$	0.091***	0.090***	−0.277***
	(0.0000644)	(0.0001699)	(0.0005108)
Market concentration hh	−0.450***	−0.468***	−1.076***
	(0.0002434)	(0.0006422)	(0.002202)
LOG(assets)	0.025***	0.025***	−0.003***
	(0.00000648)	(0.0000171)	(0.0000676)
Province dummy	Yes	Yes	Yes
Other ownership dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
Observations	2, 065, 685	2, 065, 685	538, 793
R^2	0.2061	0.0377	0.0583

Note:***Significant at the 1 percent level.

3 Benchmark Model

3.1 Model Setup

In this section, we outline a two-sector neo-classical growth model. The economy consists of four sectors: a household sector, a production sector, a banking sector and a government sector. There are three types of firms in the production sector: two intermediate firms which produce infrastructure good and general good, and a final good producer. Infrastructure good producer uses capital and unskilled labor in the production while general good producer uses capital, skilled labor and

unskilled labor. The household sector is populated with one infinitely lived representative agent who saves and makes deposit to the bank. The bank takes household's deposit and lends it to the infrastructure good producer and the general good sector. However, there is distortion in the banking sector: the two firms face different loan rates. The general good producer borrows at the market rate while the infrastructure firm borrows at a government regulated rate, which is much lower than the market rate. The following subsections detail the choice faced by the agents, the structure of production and banking, and the relevant market clearing conditions.

3.1.1 Household Sector

There is one infinitely lived representative household in this economy who has a standard CRRA preference

$$U\left(c_t\right) = \frac{c_t^{1-\gamma}}{1-\gamma} + \eta.$$

The household chooses consumption c_t, provides skilled labor s_t and unskilled labor l_t, makes a saving decision a_{t+1} to maximize his life-time utility

$$\max_{c_t, l_t, s_t, a_{t+1}} \sum_{t=0}^{\infty} \beta^t U\left(c_t\right)$$

$$\text{s.t. } c_t + a_{t+1} = w_{Lt} l_t + w_{St} s_t + (1+r_{dt}) a_t$$

In each period, the agent receives wage income by working at both infrastructure good sector and general good sector. He also receives interest r_{dt} from his bank deposit. He uses his after-tax income to consume c_t and to save a_{t+1}. Given prices $\{w_{Lt}, w_{St}, r_{dt}\}$, the following first-order conditions describe household's optimal choice:

$$\frac{U'\left(c_t\right)}{U'\left(c_{t+1}\right)} = \beta\left(1+r_{dt+1}\right); \tag{3.1}$$

$$l_t = L$$

$$s_t = S$$

3.1.2 Production Sector

There are three types of firms in this economy: an infrastructure good producer, a general good producer and a final good producer. Two intermediate goods are produced by the infrastructure sector and the general sector produce separately. The intermediate goods are then used as the inputs for final good production.

Intermediate Good Producer   Since all the intermediate good production exhibits constant return to scale, we assume that there is one competitive firm operating in each sector. The firms live for one period.

Infrastructure Good Producer   The infrastructure sector operates under the Cobb-Douglas production technology. The firm uses unskilled labor L_{It} and capital K_{It} to produce infrastructure good Y_{It}. Unskilled labor is rented from the household while capital is rented from the bank at a government-regulated rate r_{St}. The production is subject to a sectoral technology shock z_{It}.

$$Y_{It} = e^{z_{It}} A_I \left(K_{It}\right)^{1-\alpha_I} \left(L_{It}\right)^{\alpha_I} ;$$

Given factor prices $\{w_{Lt}, r_{St}, p_{It}\}$, the infrastructure firm solves the following problem

$$\max \left\{ p_{It} Y_{It} - w_{Lt} L_{It} - r_{St} K_{It} \right\} ; \tag{3.2}$$

$$w_{Lt} = \alpha_I p_{It} e^{z_{It}} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I} ;$$

$$r_{St} = (1 - \alpha_I) \, p_{It} e^{z_{It}} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{-\alpha_I} ;$$

Note that all the factor prices and good prices are measured in terms of final good.

General Good Producer   General good producer also operates under the Cobb-Douglas production function subjected to sectorial technology shock. However, besides capital K_{Ct}, he uses both skilled labor S_{Ct} and unskilled labor L_{Ct} to produce general consumption good Y_{Ct}. General good producer rents capital from the bank at the market rate r_{Lt} and rents both skilled and unskilled labor from the household at rate w_{Lt} and w_{St}. General good producer is less unskilled labor intensive than the infrastructure sector, hence $\alpha_C < \alpha_I$.

$$Y_{Ct} = e^{z_{Ct}} A_C \left(K_{Ct}\right)^{1-\alpha_C-\beta_C} \left(S_{Ct}\right)^{\beta_C} \left(L_{Ct}\right)^{\alpha_C}$$

Given factor prices $\{w_{Lt}, w_{St}, r_{Lt}, p_{Ct}\}$, the general good firm solves the following problem

$$\max \left\{ p_{Ct} Y_{Ct} - w_L L_C - w_S S_C - r_l K_C \right\} ; \tag{3.3}$$

$$w_{Lt} = \alpha_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{1-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C} ;$$

$$w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{1-\beta_C} ;$$

$$r_{Lt} = (1 - \alpha_C - \beta_C) \, p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-\beta_C};$$

Final Good Producer   The final good producer uses infrastructure good and general consumption good to produce the final good under a CES aggregator

$$Y_t = \left(\varphi \, (Y_{It})^{\frac{\sigma-1}{\sigma}} + (Y_{Ct})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}};$$

The final good firm solves the following problem in period t

$$\max \left\{Y_t - p_{It} Y_{It} - p_{Ct} Y_{Ct}\right\}$$

$$\text{s.t. } Y_t = \left(\varphi \, (Y_{It})^{\frac{\sigma-1}{\sigma}} + (Y_{Ct})^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

which leads to the first-order condition of

$$\frac{Y_I}{Y_C} = \left(\varphi \frac{p_C}{p_I}\right)^{\sigma}$$

and the standard price aggregation:

$$\left[\varphi^{\sigma} \, (p_I)^{1-\sigma} + (p_C)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} = 1;$$

3.1.3   Banking Sector

We assume there is one representative bank in the economy. This bank can convert household's savings into capital goods. For simplicity, we assume one-for-one capital formation. In each period, the bank takes household's savings, converts them into capital, and rents them to both the infrastructure firm and the general good firm. There is government distortion in the banking sector: the bank has to rent to the infrastructure firm at a lower-than-market-rate r_{St} while renting to the general good sector at market rate r_{Lt}. Since the bank makes zero profit, household's deposit rate r_{dt} is pinned down by the following condition

$$(1 + r_{dt}) \, a_t = (1 - \delta + r_s) \, K_{It} + (1 - \delta + r_l) \, K_{Ct}$$

where

$$r_{Lt} \geqslant r_{dt} \geqslant r_{St}.$$

3.1.4 Market Clearing Conditions

There are three sets of market clearing conditions: the capital market clearing, the labor market clearing and the final good market clearing. The sum of capital used in infrastructure sector and general good sector is the total capital stock in the economy.

$$K_{It} + K_{Ct} = K_t$$

The total of unskilled labor in infrastructure sector and general good sector consists of the total unskilled labor supply in the economy.

$$L_{It} + L_{Ct} = L_t$$

Finally, we have the standard final good market clearing

$$C_t + I_t = Y_t.$$

The law of motion for capital is the following

$$K_{t+1} = I_t + (1 - \delta) K_t.$$

3.2 Competitive Equilibrium

Given initial labor and capital endowment, L_{t_0}, S_{t_0}, and K_{t_0}, a set of exogenous rental rate, and sectorial TFP $\{r_{st}, A_{It}, A_{Ct}\}_{t \geq t_0}$. A *competitive equilibrium* consists of:

- Sequences of good prices and factor prices, $\{p_{It}, p_{Ct}, w_{Lt}, w_{St}, r_{dt}, r_{lt}\}_{t \geq t_0}$;

- Firms allocations, $\{K_{It}, K_{Ct}, L_{It}, L_{Ct}\}_{t \geq t_0}$;

- Household allocations, $\{c_t, a_{t+1}\}_{t \geq t_0}$;

such that:

1. Given the sequence of prices, the firm allocation solves (FP);

2. Given the sequence of prices, the household allocation solves (HP);

3. Market clearing condition:

    - Capital allocation across sectors: $K_{It} + K_{Ct} = K_t$;

- Unskilled-labor allocation across sectors: $L_{It} + L_{Ct} = L_t$;

- Goods market: $C_t + I_t = Y_t$

- Asset market: $K_{t+1} = I_t + (1 - \delta) K_t$

4. Competitive banking:

$$(1 + r_{dt}) a_t = (1 - \delta + r_{St}) K_{It} + (1 - \delta + r_{lt}) K_{Ct}.$$

3.3 Equilibrium Condition

In this section, we summarize the equilibrium conditions for this model. In an equilibrium, the following conditions must hold:

- From household side:

  - Euler equation:
  $$\frac{U'(c_t)}{U'(c_{t+1})} = \beta (1 + r_{dt+1}) ; \tag{3.4}$$

  - household budget constraint
  $$c_t + a_{t+1} = w_{Lt} l_t + w_{St} s_t + (1 + r_{dt}) a_t ; \tag{3.5}$$

- From firm side:

  - FOC for firms
  $$w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I} = \alpha_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{1-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C} ; \tag{3.6}$$

  $$w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{1-\beta_C} ; \tag{3.7}$$

  $$r_{lt} = (1 - \alpha_C - \beta_C) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C} ; \tag{3.8}$$

  $$r_{st} = (1 - \alpha_I) p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{-\alpha_I} ; \tag{3.9}$$

  - CES aggregation for final good production:
  $$Y_t = \left(\varphi (Y_{It})^{\frac{\sigma-1}{\sigma}} + (Y_{Ct})^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} ; \tag{3.10}$$

  $$\frac{Y_{It}}{Y_{Ct}} = \left(\varphi \frac{p_{Ct}}{p_{It}} \right)^{\sigma} ; \tag{3.11}$$

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$$\left[\varphi^{\sigma} \left(p_{It} \right)^{1-\sigma} + \left(p_{Ct} \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = 1; \tag{3.12}$$

– Technology:

$$Y_{It} = A_{It} \left(K_{It} \right)^{1-\alpha_I} \left(L_{It} \right)^{\alpha_I}; \tag{3.13}$$

$$Y_{Ct} = A_{Ct} \left(K_{Ct} \right)^{1-\alpha_C - \beta_C} \left(S_{Ct} \right)^{\beta_C} \left(L_{Ct} \right)^{\alpha_C}; \tag{3.14}$$

• From banking sector:

– Competitive banking:

$$\left(1 + r_{dt} \right) a_t = \left(1 - \delta + r_{st} \right) K_{It} + \left(1 - \delta + r_{lt} \right) K_{Ct}. \tag{3.15}$$

– Capital accumulation

$$K_{t+1} = I_t + \left(1 - \delta \right) K_t \tag{3.16}$$

• Market clearing conditions:

– Goods market:

$$Y_t = I_t + C_t; \tag{3.17}$$

government spending doesn't show up here because it goes into investment.

– Asset market:

$$A_t = K_t \tag{3.18}$$

– Capital allocation across sectors:

$$K_{It} + K_{Ct} = K_t; \tag{3.19}$$

– Unskilled-labor allocation across sectors:

$$L_{It} + L_{Ct} = L_t; \tag{3.20}$$

Therefore, we have 17 variables: $\{p_{It}, p_{Ct}, w_{Lt}, w_{St}, r_{dt}, r_{lt}\}$; $\{K_{It}, K_{Ct}, L_{It}, L_{Ct}, K_t, Y_{It}, Y_{Ct}, Y_t\}$; $\{C_t, I_t, A_{t+1}\}$. The equilibrium is characterized by above 17 equilibrium conditions (household's B.C. and banking's capital accumulation is for dynamics).[3]

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[3]Note that the non-arbitrage condition, i.e., equation (3.15), is redundant, given the resourse constraint.

3.4 Quantitative Analysis

In this section, we first calibrate this model to match the Chinese data. With the calibrated parameters, we first solve for steady state. Then we solve for transitional dynamics: we let the economy to start from an initial state and compute the entire path until it converges to steady state.

3.4.1 Calibration

We now proceed to choose parameter values, setting some numbers on the basis of a prior information and setting others according to the steady-state conditions. A period in the model corresponds to one year. The sample period in the data is from XX to XX. The table below summarizes calibration. [*insert detailed calibration here later on ...*]

Parameter	Description	Value
β	discount factor	0.96
γ	risk aversion	2
σ	elasticity of substitution between infrastructure and general good	2
φ	infrastructure good share	0.5
α_I	unskilled labor share for infrastructure good production	0.6
α_C	unskilled labor share for general good production	0.3
β_C	skilled labor share for general good production	0.3
δ	depreciation	0.1
A_I	technology of infrastructure production	1
A_C	technology of general consumption good production	1
L	total unskilled labor supply	20
S	total skilled labor supply	1

3.4.2 Steady State

In the steady state, we have 17 variables $\{p_I, p_C, w_L, w_S, r_d, r_L, K_I, K_C, L_I, L_C, K, Y_I, Y_C, Y, C, I, A\}$ and 17 equilibrium conditions. In the derivation below, we express all the other 16 variables in terms of p_I and use the household budget constraint to pin down p_I.

- From Euler equation,

$$r_d = \frac{1}{\beta} - 1; \tag{3.21}$$

- Firm's FOC, $r_{st} = (1 - \alpha_I) p_{It} A_{It} \left(\frac{K_{It}}{L_{It}}\right)^{-\alpha_I}$,

$$\frac{K_{It}}{L_{It}} = \left[\frac{(1 - \alpha_I) p_{It} A_{It}}{r_{st}}\right]^{\frac{1}{\alpha_I}}; \tag{3.22}$$

- Firm's FOC, $w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I}$,

$$w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I} ; \qquad (3.23)$$

- Price aggregate, $\left[\varphi^\sigma \left(p_I \right)^{1-\sigma} + \left(p_C \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = 1$,

$$p_C = \left[1 - \varphi^\sigma \left(p_I \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} ; \qquad (3.24)$$

- Firm's technology, $Y_I = A_I \left(K_I \right)^{1-\alpha_I} \left(L_I \right)^{\alpha_I}$,

$$\frac{Y_I}{L_I} = A_I \left(\frac{K_I}{L_I} \right)^{1-\alpha_I} ; \qquad (3.25)$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C} \right)^{1-\alpha_C} \left(\frac{K_C}{S_C} \right)^{-\beta_C}$, and FOC, $w_{Lt} = \alpha_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{1-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C}$,

$$\frac{Y_C}{L_C} = \frac{w_{Lt}}{\alpha_C p_{Ct}} ; \qquad (3.26)$$

- Optimal allocation across sectors, $\frac{Y_I}{Y_C} = \left(\varphi \frac{p_C}{p_I} \right)^\sigma$,

$$\frac{L_I}{L_C} = \frac{\frac{Y_C}{L_C}}{\frac{Y_I}{L_I}} \frac{Y_I}{Y_C} = \frac{\frac{Y_C}{L_C} \left(\varphi \frac{p_C}{p_I} \right)^\sigma}{\frac{Y_I}{L_I}} ; \qquad (3.27)$$

- Labor allocation, $L_I + L_C = L$;

$$L_C = \frac{L}{1 + \frac{L_I}{L_C}} ; \qquad (3.28)$$

$$L_I = L - L_C; \qquad (3.29)$$

- Capital, output allocation:

$$K_I = L_I \left(\frac{K_I}{L_I} \right) ; \qquad (3.30)$$

$$Y_I = L_I \left(\frac{Y_I}{L_I} \right) ; \qquad (3.31)$$

$$Y_C = L_C \left(\frac{Y_C}{L_C} \right) ; \qquad (3.32)$$

- Goods market clear condition:

$$C = \left(\varphi \left(Y_{It} \right)^{\frac{\sigma-1}{\sigma}} + \left(Y_{Ct} \right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} - \delta K; \qquad (3.33)$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C}\right)^{1-\alpha_C} \left(\frac{K_C}{S_C}\right)^{-\beta_C}$,

$$K_C = \left[\frac{\frac{Y_C}{L_C}(L_C)^{1-\alpha_C}(S_C)^{-\beta_C}}{A_C}\right]^{\frac{1}{1-\alpha_C-\beta_C}} ; \qquad (3.34)$$

- Firm's FOC, $w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{1-\beta_C}$, and $r_{lt} = (1-\alpha_C-\beta_C) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-}$

$$w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{1-\beta_C} \qquad (3.35)$$

$$r_{lt} = (1-\alpha_C-\beta_C) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-\beta_C} ; \qquad (3.36)$$

- Then, we can use B.C. to pin down p_I :

$$C + \overline{\tau} = w_L L + w_S S + r_d A$$

$$C = w_L L + w_S S + r_d K - (1+r_d)\overline{\tau}; \qquad (3.37)$$

- No-arbitrage condition in banking sector, $(1+r_d)K = (1-\delta+r_S)K_I + (1-\delta+r_L)K_C$ are automatically satisfied.

Given the calibration and our algorithm described just now, we can solve for steady state. We first solve the case when the government imposed a state interest rate for the infrastructure sector $r_S = 0.11$ and zero lump-sum tax $\tau = 0$. In steady state, we have $r_d = 0.0417$, $r_L = 0.1879$. The corresponding effective state interest rate $(r_S - \delta)$ is 0.01 and effective market rate $(r_L - \delta)$ is 0.0897. The market rate $r_L - \delta$ is much higher than the state rate $r_S - \delta$ while the deposit rate r_d lies between the market rate and the deposit rate. The wage premium is positive with $w_L = 0.51$ and $w_S = 3.78$. The prices of the intermediate goods in terms of final goods are $p_I = 0.54$ and $p_C = 1.86$. Steady state capital level is 65.94.

We also computed the case where there is no government distortion. In this case, all the interest rates are equal: $r_S - \delta = r_L - \delta = r_d = 0.0417$. The unskilled labor wage is $w_L = 0.51$, the skilled labor wage is $w_S = 4.22$. The prices of the intermediate goods in terms of final goods are $p_I = 0.60$ and $p_C = 1.71$. Steady state capital level is 68.07 which is higher than the case with distortion.

3.4.3 Algorithm for Computing Transition Path

Shooting method is used to solve the trasitional dynamics. We compute a path where the economy starts from a given state and eventually goes back to steady state. We assume it takes less than $T = 100$ periods for the economy to go back to steady state. The shooting algorithm is described as follow:

1. The economy starts from an initial capital stock level K_1. We guess a range $[\underline{K}, \overline{K}]$ for second period capital level K_2.

2. Let $K_2 = (\underline{K} + \overline{K})/2$. Given K_1 and K_2, we can solve the system for T periods.

    (a) Given K_t, we could solve for static variables $\{p_{Ct}, p_{It}, L_{Ct}, L_{It}, K_{Ct}, K_{It}, Y_{Ct}, Y_{It}, w_{Lt}, w_{St}, r_{Lt}, r_{dt}\}$ in period t.

    (b) Similarly given K_{t+1}, we solve the the static variables in period $t + 1$: $\{p_{Ct+1}, p_{It+1}, L_{Ct+1}, L_{It+1}, K_{Ct+1}, K_{It+1}, Y_{Ct+1}, Y_{It+1}, w_{Lt+1}, w_{St+1}, r_{Lt+1}, r_{dt+1}\}$.

    (c) Since we know $\{w_{Lt}, w_{St}, r_{dt}, K_t, K_{t+1}\}$, c_t is solved from household's budget constraint.

    (d) From Euler equation
    $$\frac{U'(c_t)}{U'(c_{t+1})} = \beta(1 + r_{dt+1})$$
    we know c_{t+1}.

    (e) Given $\{c_{t+1}, w_{Lt+1}, w_{St+1}, r_{dt+1}, K_{t+1}\}$, from household budget constraint we can solve for K_{t+2}.

    (f) Since we solved for K_{t+2}; repeat the procedure (a)-(e), we can solve for $K_{t+3}, K_{t+4}, \ldots K_T$.

3. If the value of K_2 we guessed above is higher than its true value, the economy will accumulate more and more capital, and thus eventually diverge with either $c_t \leq 0$ or $r_{dt} \leq 0$ at some point in the future. Similarly, if the guess of K_2 is too low, the economy will consume too much and thus accumulate less and less capital. Eventually, the economy will diverge with If $K_t \leq 0$. Therefore, in any period t,

    (a) If $c_t \leq 0$ or $r_{dt} \leq 0$, then $\overline{K} = K_2$ and go back to step 2.

    (b) If $K_t \leq 0$, then $\underline{K} = K_2$ and go back to step 2.

4. If $|\overline{K} - \underline{K}| \leq 10^{-15}$ then stop. Otherwise, go back to step 2.

We describe the details in 2.(a) and (b) here. Given any K_t using equation (3.38) - (3.51), we can rewrite $\{p_{Ct}, L_C, L_I, K_C, K_I, Y_C, Y_I, w_L, w_s, r_l\}$ as functions of p_{It}. Then we could use equation (3.52) to pin down p_{It}. Immediately, we can solve for r_{dt} by non-arbitrage condition (3.53).

- Firm's FOC, $r_{st} = (1 - \alpha_I) p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{-\alpha_I}$,

$$\frac{K_{It}}{L_{It}} = \left[\frac{(1 - \alpha_I) p_{It} A_{It}}{r_{st}} \right]^{\frac{1}{\alpha_I}} ; \tag{3.38}$$

- Firm's FOC, $w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I}$,

$$w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1-\alpha_I} ; \tag{3.39}$$

- Price aggregate, $\left[\varphi^\sigma (p_I)^{1-\sigma} + (p_C)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = 1$,

$$p_C = \left[1 - \varphi^\sigma (p_I)^{1-\sigma} \right]^{\frac{1}{1-\sigma}} ; \tag{3.40}$$

- Firm's technology, $Y_I = A_I (K_I)^{1-\alpha_I} (L_I)^{\alpha_I}$,

$$\frac{Y_I}{L_I} = A_I \left(\frac{K_I}{L_I} \right)^{1-\alpha_I} ; \tag{3.41}$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C} \right)^{1-\alpha_C} \left(\frac{K_C}{S_C} \right)^{-\beta_C}$, and FOC, $w_{Lt} = \alpha_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{1-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C}$,

$$\frac{Y_C}{L_C} = \frac{w_{Lt}}{\alpha_C p_{Ct}} ; \tag{3.42}$$

- Optimal allocation across sectors, $\frac{Y_I}{Y_C} = \left(\varphi \frac{p_C}{p_I} \right)^\sigma$,

$$\frac{L_I}{L_C} = \frac{\frac{Y_C}{L_C}}{\frac{Y_I}{L_I}} \frac{Y_I}{Y_C} = \frac{\frac{Y_C}{L_C} \left(\varphi \frac{p_C}{p_I} \right)^\sigma}{\frac{Y_I}{L_I}} ; \tag{3.43}$$

- Labor allocation, $L_I + L_C = L$;

$$L_C = \frac{L}{1 + \frac{L_I}{L_C}} ; \tag{3.44}$$

$$L_I = L - L_C; \tag{3.45}$$

- Capital, output allocation:

$$K_I = L_I \left(\frac{K_I}{L_I} \right) ; \tag{3.46}$$

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$$Y_I = L_I \left(\frac{Y_I}{L_I} \right); \tag{3.47}$$

$$Y_C = L_C \left(\frac{Y_C}{L_C} \right); \tag{3.48}$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C} \right)^{1-\alpha_C} \left(\frac{K_C}{S_C} \right)^{-\beta_C}$,

$$K_C = \left[\frac{\frac{Y_C}{L_C} (L_C)^{1-\alpha_C} (S_C)^{-\beta_C}}{A_C} \right]^{\frac{1}{1-\alpha_C-\beta_C}}; \tag{3.49}$$

- Firm's FOC, $w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{1-\beta_C}$, and $r_{lt} = (1 - \alpha_C - \beta_C) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-}$

$$w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{1-\beta_C} \tag{3.50}$$

$$r_{lt} = (1 - \alpha_C - \beta_C) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}} \right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}} \right)^{-\beta_C}; \tag{3.51}$$

Then, we can use $K_{It} + K_{Ct} = K_t$ to pin down p_{It}.

$$K_{It} + K_{Ct} = K_t \tag{3.52}$$

and solve for r_{dt}

- Competitive banking:

$$(1 + r_{dt}) A_t = (1 - \delta + r_{st}) K_{It} + (1 - \delta + r_{lt}) K_{Ct}. \tag{3.53}$$

3.5 Results

We would like to study the effect of a gradually introduced interest rate distortion on the economy. First, the economy stays on the balanced growth path where there are no distortion. The three interest rates are all equal, i.e., $r_d = r_s - \delta = r_l - \delta$. Then, the government starts to subsidize the infrastructure sector by providing loan with lower than market interest rate, $r_s < r_l$.

In our numerical exercise, the initial loan rate for the infrastructure sector, r_s, is set at the non-distortionary level, $r_s = r_d^{ss} + \delta = 0.1417$. After 10 periods, the government starts to subsidize the infrastructure sector by gradually pushing down the loan rate to $r_S = 0.105$ (We assume it takes 10 periods to reach r_S). The path of r_S is shown in the figure below.
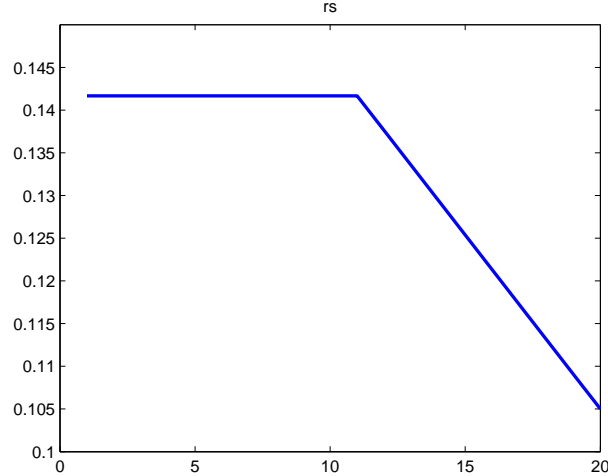
3.5.1 Factor Prices and Allocations

Figure X shows the changes in wages, interest rates and capital labor allocations along the transitional path. As government introduces low interest rate for the infrastructure sector from period 10 to period 20, we observe sustaintial changes in the factor prices and allocations. First of all, we observe that unskilled labor wage increases and skilled labor wage decreases. With these changes, the relative wage for unskilled labor increases substantially. Second, the market loan rate increases sharply and the deposit rate falls. Third, capital and labor all shift to the infrastrucuture sector. All these predications are consistent with our data observations discussed in the previous section. The intuition behind the changes is the following. As the lower interest rate is introduced to the infrastructure sector, investment flows into the infrastructure sector. When the firms in infrastructure sector increase their capital stock, they also hire more unskilled workers. Threrefore we observe that capital and unskilled labor are moving from the consumption sector to the infrastructure sector. In other words, as the interest rate falls, the infrastructure sector crowds out the consumption sector. The increasing demand for unskilled labor from the expanding infrastructure sector drives up unskilled wage. On the other hand, the shrinking consumption sector demands less skilled labor which leads to a decrease of skilled labor wage.

As infrastructure sector takes out most of the available capital, the falling supply of capital drives up the market interest rate. Given that the bank makes zeros profit, the fall in the deposit rate represents a fall in the average rate of return to capital in the economy. Hence in this model, we see that although investment increases a lot, the average return is low. The intuition is straight-

forward: infrastructure sector can rent the capital at a lower cost, they tend to invest more and the marginal return to capital is low; the other sectors has to rent the capital at market rate, which is distortionarily higher. The aggregate rate of return to capital is lower.
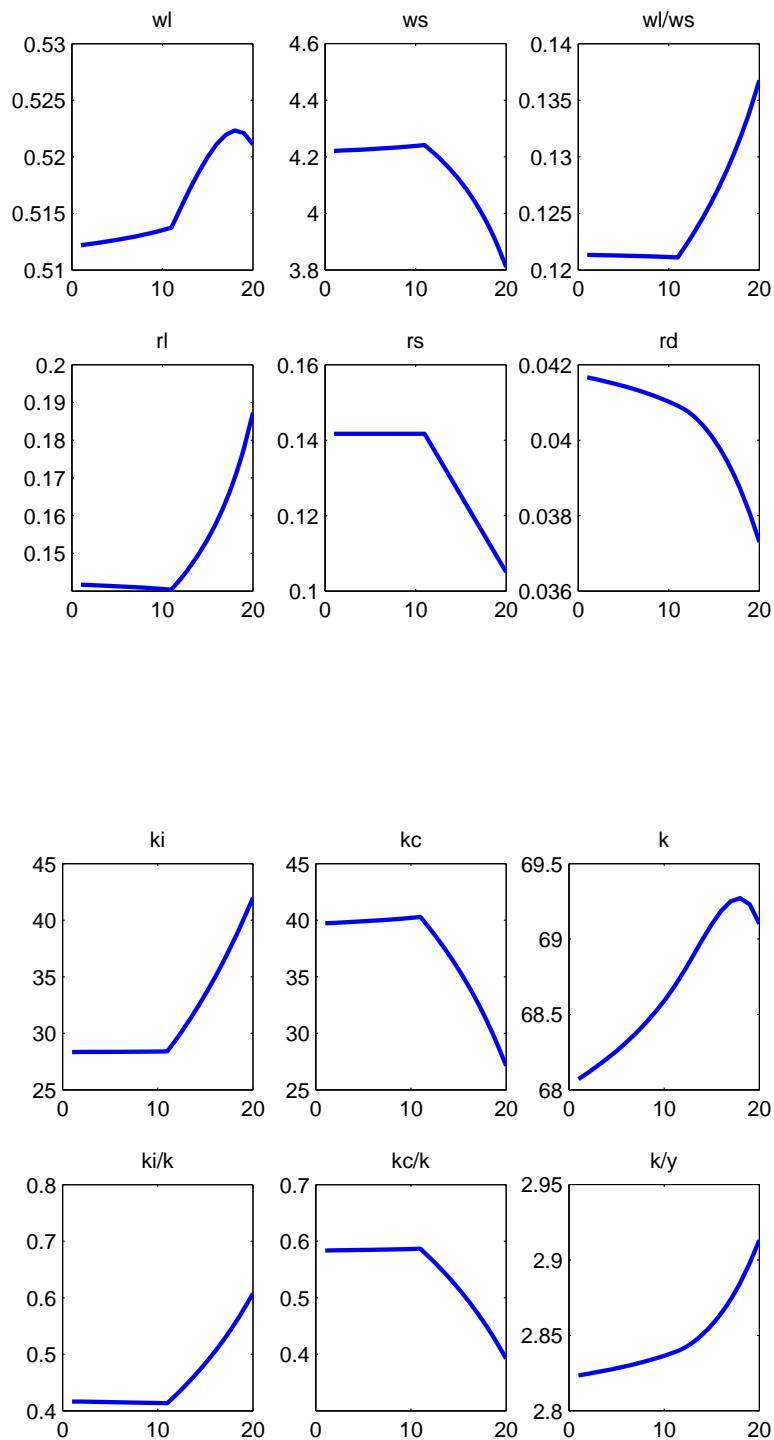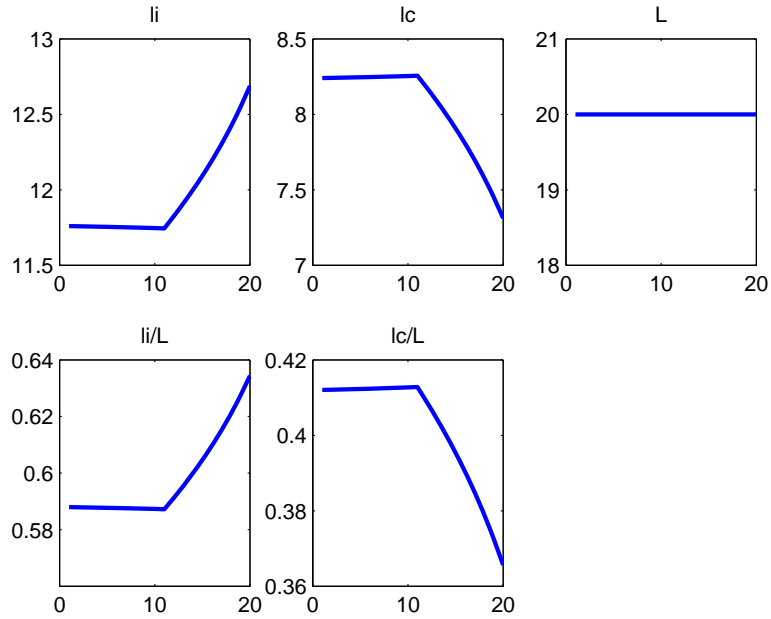
3.5.2 Aggregate Output and Consumption

Figure X shows the changes in the output and consumption level. We observe that the output of infrastructure rises while the output of consumption sector falls. This is consistent with the rising capital stock and labor employed in the infrastructure sector and falling capital and labor in the consumption sector. More interestingly, the aggregate output increase initially, however, it falls soom after a boom. On the other hand, the consumption falls during the entire transitional period. An interesting implication of our results is that for a government who is interested in the short-run output level, it will have a strong incentive to apply such distortionary policy to promote the output, even though such a policy does not generate more consumption and eventually the output level indeed falls because of the distortions. This finding may also explain the high debt level of the local government across China, when local governments have strong incentives to investment in the subsidized sector, they borrow more.
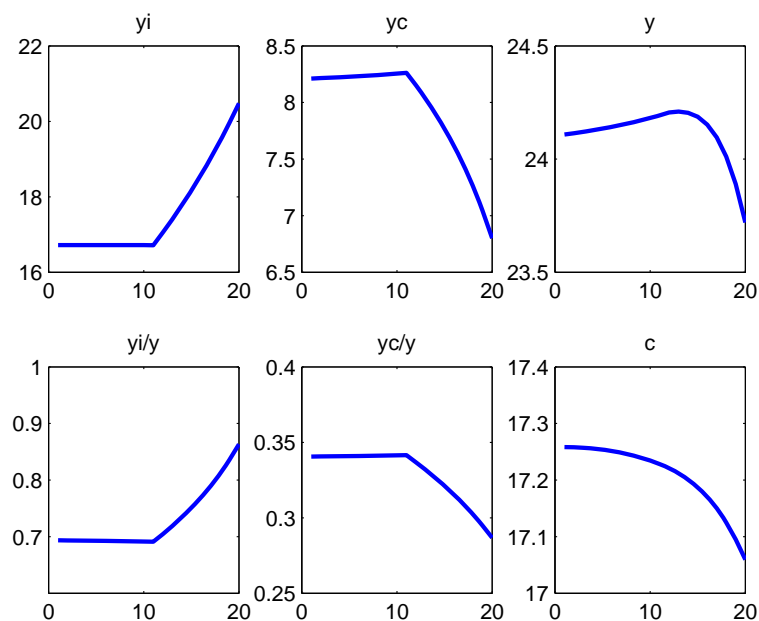
4   An Extended Model with Rural/Urban Migration

During the chinese transitional period, we observe a large amount of reallocation of labor force across sectors. A remarkable fact is the large scale migration of unskilled labor from rural area to urban industry. The migration, among which are unskilled labor, occurred at 1978 with the amount of 2 million, and has surged up to 145.33 million in 2009. By the third quarter of 2013, migrant workers numbered 173.92 million. The mobilization of labor from rural area provides excess supply of unskilled labor to urban industry, which contribute to the persistent growth of Chinese economy.
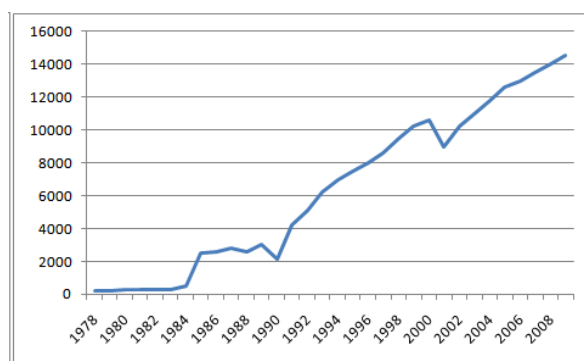
Figure 5; Source: China Statistical Yearbook, 2013.

In this section, we relax the assumption that the total population is fixed and study a model

where there is excess labor supply. The economy has a rural sector and an urban sector. In the rural sector, unskilled workers are engaged in subsistence agriculture whose output is consumed only in the rural area. In the urban sector, similar to the previous set up, two types of goods are produced using inputs of unskilled labor, skilled labor, and capital. The economy's supply of skilled labor and unskilled labor is exogenously given, although the allocation of unskilled labor between the rural and urban sectors is driven by household migration decisions. The supply of capital to the urban sector is assumed to be endogenously determined by the savings decisions of urban households.

4.1 The Rural Area

In this section, we describe the production in the rural area and derive the conditions determining the allocation of unskilled labor between the rural and urban areas. The total population of the unskilled labor is denoted by $\bar{N}$ which consists of a group of size N residing in the rural area and a group of size L located in the urban area.

4.1.1 Subsistence Farming

The production technology in the rural is described as follows:[4]

$$y = \begin{cases} A_r E^{1-\alpha_R} N^{\alpha_R}; & N < N_R \\ \bar{C}; & N \geq N_R \end{cases} ;$$

where E is land, N is unskilled labor input and $N_R = \left(\frac{\bar{C}}{A_r E^{1-\alpha_R}} \right)^{\frac{1}{\alpha_R}}$. This production technology represents the idea that when population is above certain shreshold, increasing labor input will not increase the total output. Therefore, the MPL for unskilled labor in rural area follows such a step function:

$$MPL = \begin{cases} \alpha_R A_r E^{1-\alpha_R} N^{\alpha_R-1}; & N < N_R \\ 0; & N \geq N_R \end{cases} .$$

Note that if the population above the threshold N_R moves into urban industry, then their MPL will change from zero to a positive number.

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[4]As the first step, we can assume that $\alpha_R = 1$, which means that we don't consider the contribution of land for now.

4.1.2 Migration Cost

The unskilled labor can choose to move to urban area to work, and thus enjoy the final urban goods. However, they need to pay a migration cost $D(L, l)$, which is described by

$$D(L, l) = \phi_0 \left(\frac{L}{\bar{N} - N_R} \right)^{-\xi} \frac{l^{1+\psi}}{(1+\psi)};$$

where $\bar{N}$ is the total number of unskilled labor in the economy, l is the number of migrants who chooses to move to urban area, and L is the total number of unskilled labor located in the urban area. Note that l is a choice variable for the rural household, and L is an aggregate variable which is taken as given when making the migration decision. The above migration cost function shows externality of migration: the more unskilled labor migrates, the smaller the cost of migration. ξ here captures the effect of such an externality.

We can conjecture that if the government subsidizes the infrastructure sector which increases employment of unskilled worker, then the migration cost is lower and migration is hence encouraged. Given that the unskilled worker moves into the urban industry, the productivity is increased and the government distortionary policy is welfare enhancing. However, once the migration is complete, the government distortionary policy will reduce the welfare as discussion in the previous set up.

4.1.3 The Rural/Urban Migration Decision

By migrating to the urban area, an unskilled worker earns the unskilled wage w and consumes instead the aggregate good Y. For the representative worker who migrates into the urban area, we have

$$w_L = \phi_0 \left(\bar{N} - N_R \right)^{\xi} L^{-\xi} l^{\psi}.$$

If the total population of the unskilled worker already moved into the urban area, then $L = \bar{N} - N_R$. This gives us the threshold migration wage $\bar{w}$

$$\bar{w} = \phi_0 \left(\bar{N} - N_R \right)^{\psi}$$

For wages lower than the threshold, only part of the unskilled population moves into the urban area. Therefore the migration condition is

$$L = \begin{cases} \left(\frac{w_L}{\phi_0 (\bar{N} - N_R)^{\xi}} \right)^{\frac{1}{\psi - \xi}}; & w_L < \bar{w} \\ \bar{N} - N_R; & w_L \geq \bar{w} \end{cases}.$$

4.2 The Urban Area

The urban area is modelled the same way as the benchmark model. The only difference here is that the total supply of unskilled labor may depend on the stage of the economy. In particular, there are two stages of the economy:

1. Stage 1: there exists abundant unskilled labor supply

    At this stage, only a part of the unskilled labor from the rural area moves to the urban area. The total labor supply is given by $L = \left(\frac{w}{\phi_0 (\bar{N} - N_R)^\xi} \right)^{\frac{1}{\psi - \xi}} < (\bar{N} - N_R)$.

2. Stage 2: all unproductive unskilled labors have already moved to urban area

    At this stage, the total labor supply in urban sector is $(\bar{N} - N_R)$. The model works the same way as our benchmark model.

4.3 Equilibrium Conditions

We assume that the economy starts from a state where there is potential future migration. During the migration phase, we can write $\{p_{Ct}, L_C, L_I, K_C, K_I, Y_C, Y_I, w_L, w_s, r_l\}$ as a function of p_{It} and L. Then using equation (4.15) and (4.16) to pin down p_{It} and L. Once the factor allocations and prices are solved, we solve for r_{dt} by non-arbitrage condition and then c_t by budget constraint. For every period, we check if $L = (\bar{N} - N_R)$ holds. Once $L = (\bar{N} - N_R)$, then for all the periods that follow we solve the equilibrium as in section 6.3.

- Firm's FOC, $r_{st} = (1 - \alpha_I) p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{-\alpha_I}$,

$$\frac{K_{It}}{L_{It}} = \left[\frac{(1 - \alpha_I) p_{It} A_{It}}{r_{st}} \right]^{\frac{1}{\alpha_I}} ; \tag{4.1}$$

- Firm's FOC, $w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1 - \alpha_I}$,

$$w_{Lt} = \alpha_I p_{It} A_{It} \left(\frac{K_{It}}{L_{It}} \right)^{1 - \alpha_I} ; \tag{4.2}$$

- Price aggregate, $\left[\varphi^\sigma (p_I)^{1 - \sigma} + (p_C)^{1 - \sigma} \right]^{\frac{1}{1 - \sigma}} = 1$,

$$p_C = \left[1 - \varphi^\sigma (p_I)^{1 - \sigma} \right]^{\frac{1}{1 - \sigma}} ; \tag{4.3}$$

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- Firm's technology, $Y_I = A_I \left(K_I\right)^{1-\alpha_I} \left(L_I\right)^{\alpha_I}$,

$$\frac{Y_I}{L_I} = A_I \left(\frac{K_I}{L_I}\right)^{1-\alpha_I}; \qquad (4.4)$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C}\right)^{1-\alpha_C} \left(\frac{K_C}{S_C}\right)^{-\beta_C}$, and FOC, $w_{Lt} = \alpha_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{1-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-\beta_C}$,

$$\frac{Y_C}{L_C} = \frac{w_{Lt}}{\alpha_C p_{Ct}}; \qquad (4.5)$$

- Optimal allocation across sectors, $\frac{Y_I}{Y_C} = \left(\varphi \frac{p_C}{p_I}\right)^{\sigma}$,

$$\frac{L_I}{L_C} = \frac{\frac{Y_C}{L_C}}{\frac{Y_I}{L_I}} \frac{Y_I}{Y_C} = \frac{\frac{Y_C}{L_C} \left(\varphi \frac{p_C}{p_I}\right)^{\sigma}}{\frac{Y_I}{L_I}}; \qquad (4.6)$$

- Labor allocation, $L_I + L_C = L$;

$$L_C = \frac{L}{1 + \frac{L_I}{L_C}}; \qquad (4.7)$$

$$L_I = L - L_C; \qquad (4.8)$$

- Capital, output allocation:

$$K_I = L_I \left(\frac{K_I}{L_I}\right); \qquad (4.9)$$

$$Y_I = L_I \left(\frac{Y_I}{L_I}\right); \qquad (4.10)$$

$$Y_C = L_C \left(\frac{Y_C}{L_C}\right); \qquad (4.11)$$

- Firm's technology, $\frac{Y_C}{L_C} = A_C \left(\frac{K_C}{L_C}\right)^{1-\alpha_C} \left(\frac{K_C}{S_C}\right)^{-\beta_C}$,

$$K_C = \left[\frac{\frac{Y_C}{L_C} \left(L_C\right)^{1-\alpha_C} \left(S_C\right)^{-\beta_C}}{A_C}\right]^{\frac{1}{1-\alpha_C-\beta_C}}; \qquad (4.12)$$

- Firm's FOC, $w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{1-\beta_C}$, and $r_{lt} = \left(1 - \alpha_C - \beta_C\right) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-}$

$$w_{St} = \beta_C p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{1-\beta_C} \qquad (4.13)$$

$$r_{lt} = \left(1 - \alpha_C - \beta_C\right) p_{Ct} A_{Ct} \left(\frac{K_{Ct}}{L_{Ct}}\right)^{-\alpha_C} \left(\frac{K_{Ct}}{S_{Ct}}\right)^{-\beta_C}; \qquad (4.14)$$

Then, we can use the following equations to pin down p_{It} and L

$$K_{It} + K_{Ct} = K_t \tag{4.15}$$

$$L = \left(\frac{w_L}{\phi_0 \left(\bar{N} - N_R \right)^{\xi}} \right)^{\frac{1}{\psi - \xi}} \tag{4.16}$$

4.4   Calibration: Rural Area

The parameter values for the urban economy are set the same level as before. The new parameters for the rural area and migration cost are set as follows:

$\bar{N}$	$\bar{C}$	ϕ_0	ξ	ψ	α_R	E	A_R	$\bar{U}$
25	5	0.0011	1	2	1	1	1	-2

4.5   Results

We follow the same government distortionary policy as in the previous section. First, the economy stays on the balanced growth path where there are no distortions for 10 periods, then government starts to subsidize the infrastructure sector by gradually pushing down the loan rate for another 10 periods. The path of r_S is shown in the figure below.
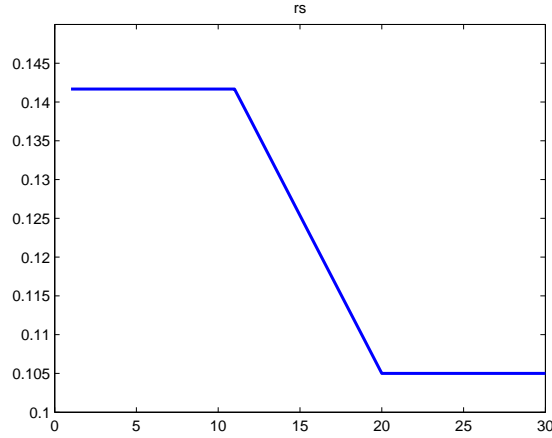
In the following section, we summarize the effect of the policy on the key macroeconomic variables for two cases: the economy with migration and the economy without migration.[5]

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[5] To illustrate the effect of the distortionary policy on the economy, we only show the first 30 period of the transition path. We summarize the full path of the transition dynamics in the Appendix A.

4.5.1   Factor Allocations and Prices

The figures below show the changes in the factor allocations and prices. The solid line shows the paths where where the country has a rural area and the dash line shows that case that the urban area is absent. Given government's distortionary policy, we obtain similar results as in Section 3.

We observe that the rise in unskilled labor wage and the fall in the skilled labor wage leads to a declining of wage premium. The market loan rate increases sharply and deposit interest rate does not change that much. It falls at first and then returns back to its original level gradually. Capital and labor move from the consumption sector to the infrastructure sector. Moreover, part of the unskilled population moves from the rural area into the urban area.

The logic is the following. As the lower interest rate is introduced to the infrastructure sector, investment flows into the infrastructure sector. When the firms in infrastructure sector increase their capital stock, they also hire more unskilled workers. Threrefore we observe that capital and unskilled labor are moving from the consumption sector to the infrastructure sector. In other words, as the interest rate falls, the infrastructure sector crowds out the consumption sector. The increasing demand for unskilled labor from the expanding infrastructure sector drives up unskilled wage. Therefore the unskilled worker moves from rural area into the urban industry. On the other hand, the shrinking consumption sector demands less skilled labor which leads to a decrease of skilled labor wage. Note that not all the population in the rural area moves into the urban industry, this is because that the unskilled wage is not high enough at this stage. To sum up, the movements in the factor allocation and prices are similar for the two cases except that part of the rural population moves into the urban industry in the extended model.
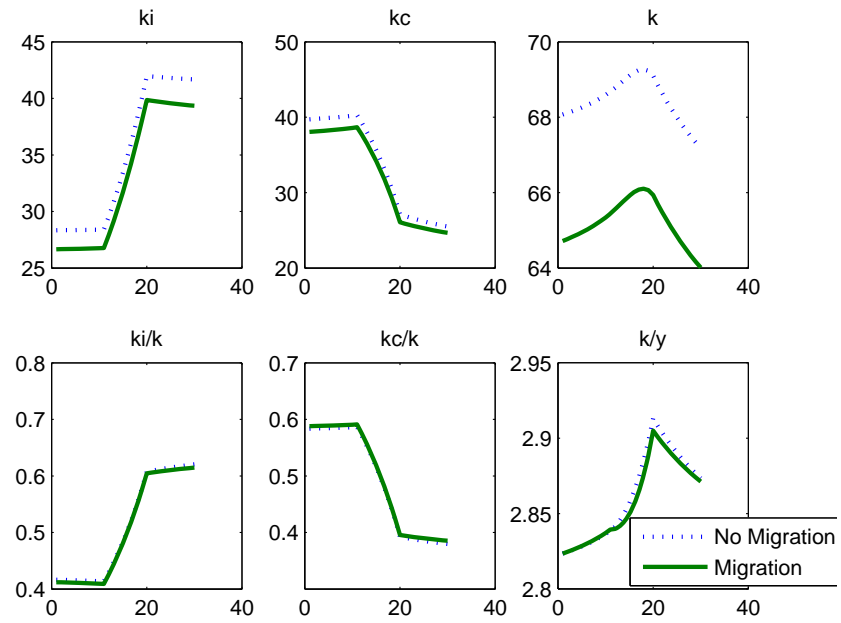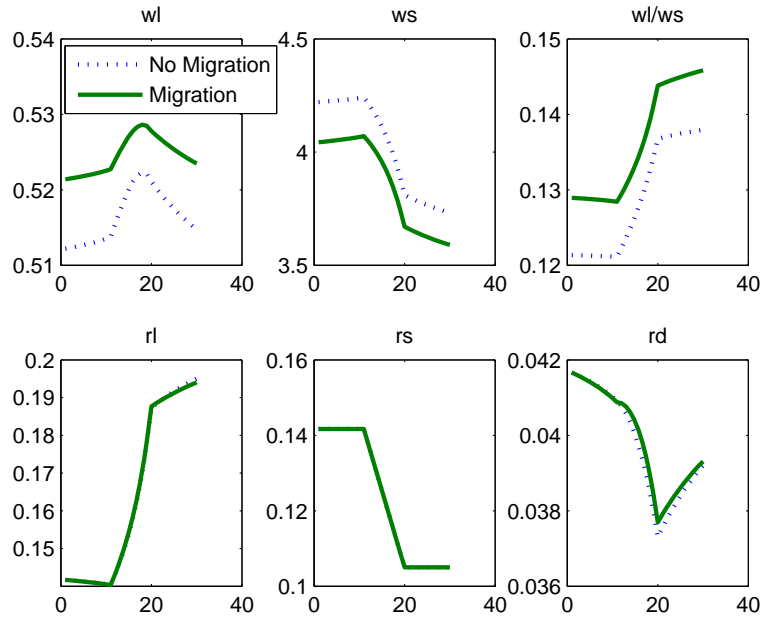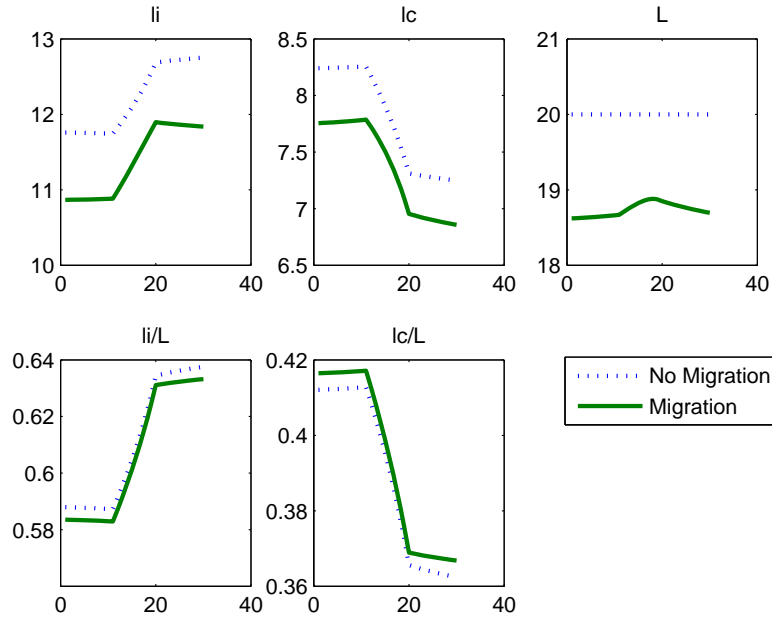
4.5.2 Aggregate Output and Consumption

The implications on output and consumption level are more interesting. Figure X shows the trasitional path of ouput and consumption level. The pattern of consumption is clearly different. For the case with migration, consumption increases and then falls. However, for the case without migration, the consumption level falls right from the beginning. The movements of the rest of the macro variables are the same for the two cases. The infrastructure sector expands due to the distortionary policy and the consumption good sector shrinks. Output experiences a short-lived boom and falls back to distortionary steady state.

The difference in the consumption pattern is because when unskilled worker moves from the rural area into the urban area, their marginal product of labor increases. Hence their consumption level rises from the subsistence level to the urban household level. The interesting implication of this finding is that there is a trade-off between reallocating the unskilled labor to more productive sector and government biased investment policy. If there is excess labor supply, biased investment policy would potentially increase the aggregate consumption level in short-run. Hence the government can increase output and consumption at the same time.
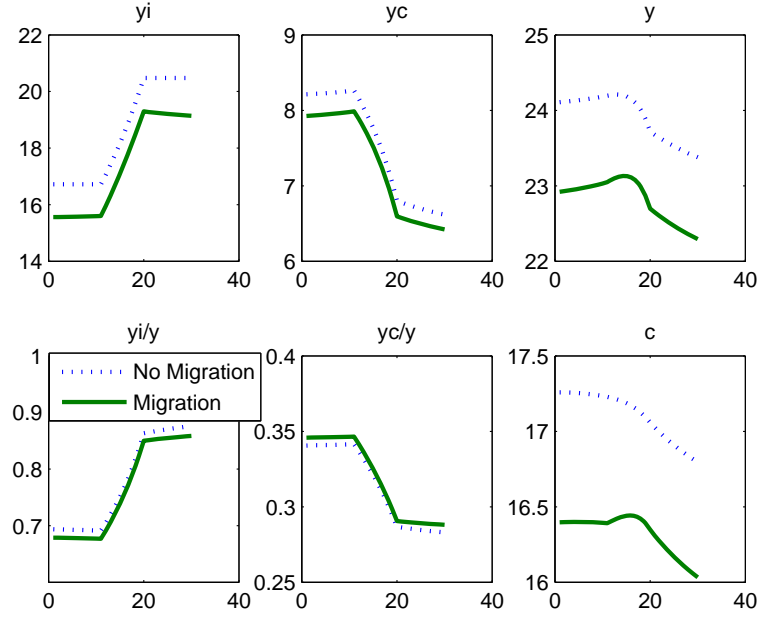
5 Discussion

5.1 Welfare

Note that the gap between subsidized rate, r_s, and market rate, r_l, actually captures the degree of distortion in our economy. We compute the welfare loss associated with the distortion, by comparing welfare under economy with and without distortion. Our results clearly show that when the economy has a fixed labor supply, the welfare loss increases with the degree of the distortion. However, when there is excess labor supply, distortionary government policy could actually increase welfare. When the distortion is relatively small, as it increases, the welfare is improving. After certain degree of distortion, the economy still benefits from the policy by having a welfare gain, however, the size of welfare gain is falling. The inverse U-shaped welfare gain reflects trade-off between two forces: when unskilled labor moves into more productive sector, welfare increases. When government distortionary interest rate misallocates the resources within the economy, the welfare falls. Therefore, there exists an optimal extent of intervetion of government distortionary policy.

welfare loss in %
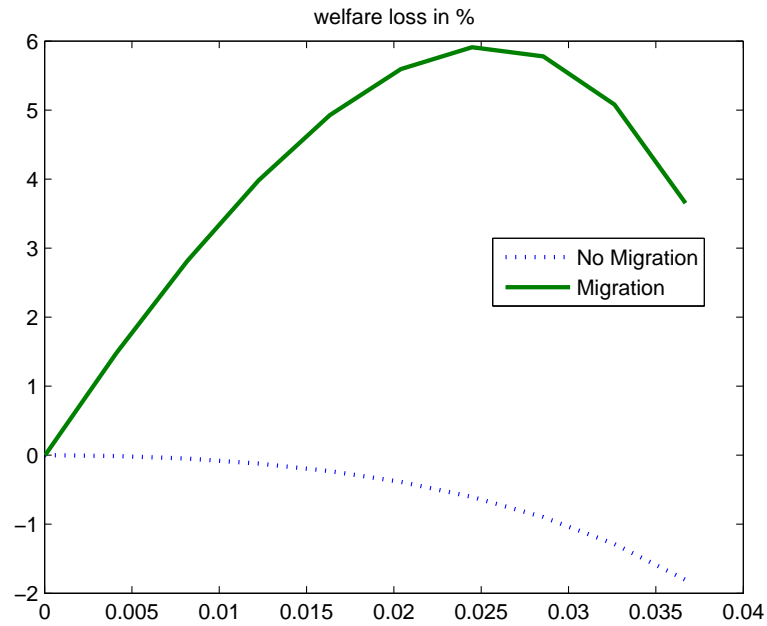
5.2   Migration Externality

We explores the relationship between migration cost and the migration speed here. The figure below shows the population size in the urban area for different migration costs. We assume that the economy faces a permanent level of interest rate distortion. These three cases all start from the same level of capital stock. A smaller ξ represents a lower degree of externality and hence a higher migration cost. The figure shows that when the migration cost is high, the migration speed is low as demonstrated by the slope of the population line.
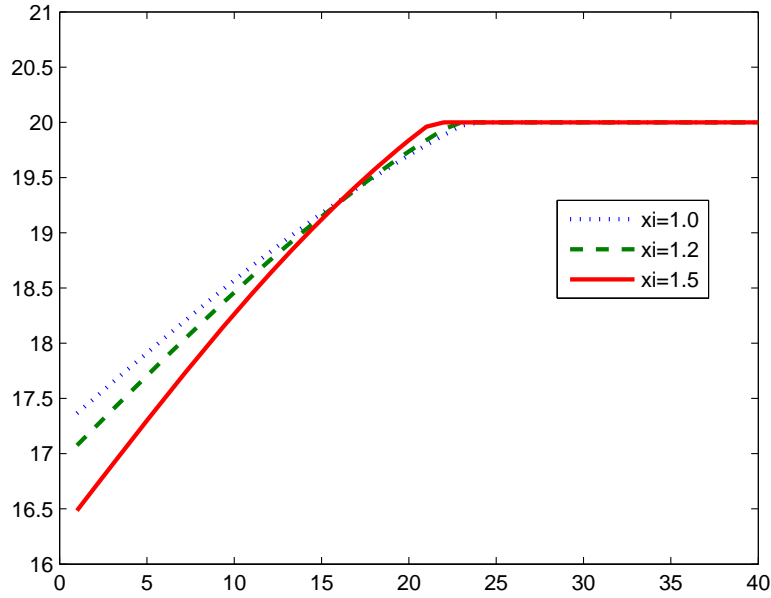
5.3 Transition Dynamics from an off-balanced-path Initial State

In previous section, we assume that the economy initially stays at steady state, and thus examine how it reacts when applying the distortionary policy. Therefore, the results illustrated above indeed capture the short-run effect of policies. However, it is also interesting to examine the long run effect of such policies on the economy during its transitional stage. In this section, we assume the economy still locates on its transition path to the S.S.. In particular, the initial capital stock of the economy is only half of its steady state level. To show the long-run effect of distortionary policy, we compare the transition path of the economy with distortion to that without distortion. Similarly, we consider two scenarios: i) economy with no migration; ii) economy with migration from rural area Interestingly, the transition paths under long run distortionary policies presents quite different patterns than previous sections. We summarize our results in Appendix B.

5.4 Implications on Education Policy

Our current framework also has important implications on the education policy. China started to expand its college enrollment from 1999 and this policy has always been critisized as the reason for falling college wage premium. If declining wage premium is due to expansion of college enrollment, then we should probably enroll fewer college students. However, our model implies that the decline

of wage premium may not be due to college expansion. The evidence is that, if supply of skilled labor increases, we should see the expansion of skilled labor intensive sectors, but we observe the opposite in the data. This rules out the supply side story and leads to our demand side story: demand of skilled labor is low due to capital market distortions, so wage premium declines and skilled labor intensive sectors grow slower.

5.5 Robustness

We experimented with different sets of parameter values, and the transition patterns under both short-run policy and long-run policy are pretty much the same.

6 Conclusions

In this paper, we build a two-sector growth model with government policy biased towards the infrastructure sector. The model is consistent with salient features of the Chinese economy. Our model can explain i) The skill premium in wage has been rising till 2008 but falls afterwards; ii) the aggregate investment rate in China increases from 42% in 2008 to 47% in 2013, among which structure investment contributes most of the surge; iii) on the firm level, the return to capital is lower for the firms with lower averaging schooling year. A calibrated version of the model is shown to be consistent with the above facts.

We believe that the model has many important policy implications. First of all, there is an optimal extent of intervention on subsidizing investment. When the rural area has excess supply of labor, subsidizing infrastructure sector could increase total productivity and at the same time increases welfare. However, when the migration is finished, the intervention could only increase output while reduces welfare. Second, when the government is only interested in the short-run output level, then it has strong incentive to subsidize the infrastructure sector. This helps to explain the high local government debt in China during recent years. Finally, this model also has implication on the enducation policy. We show that the expansion of college enrollment is not the main driving force for the declining wage premium.

Appendix A

Here we show the full transition paths of the economy when they choose to apply the distortionary policy at period 10.
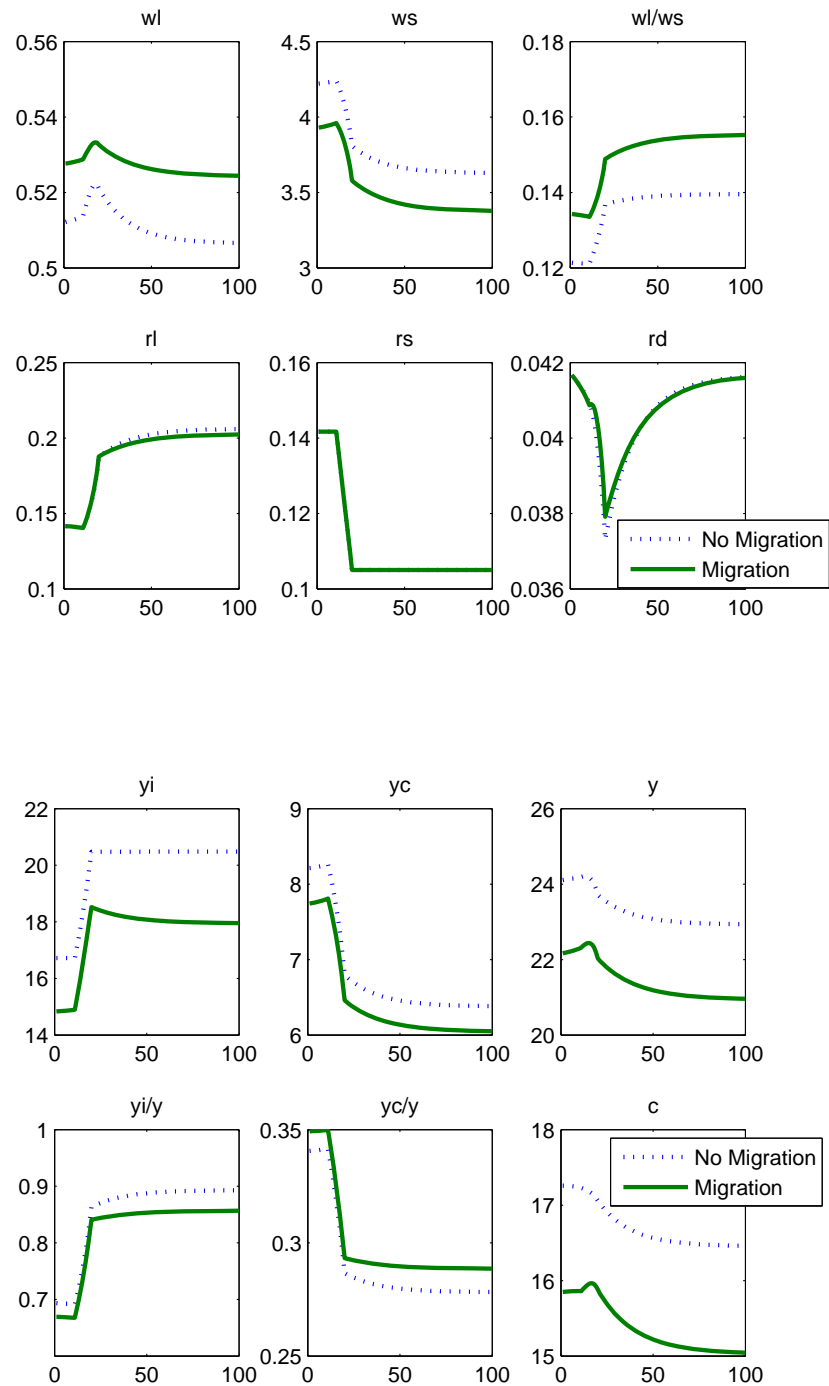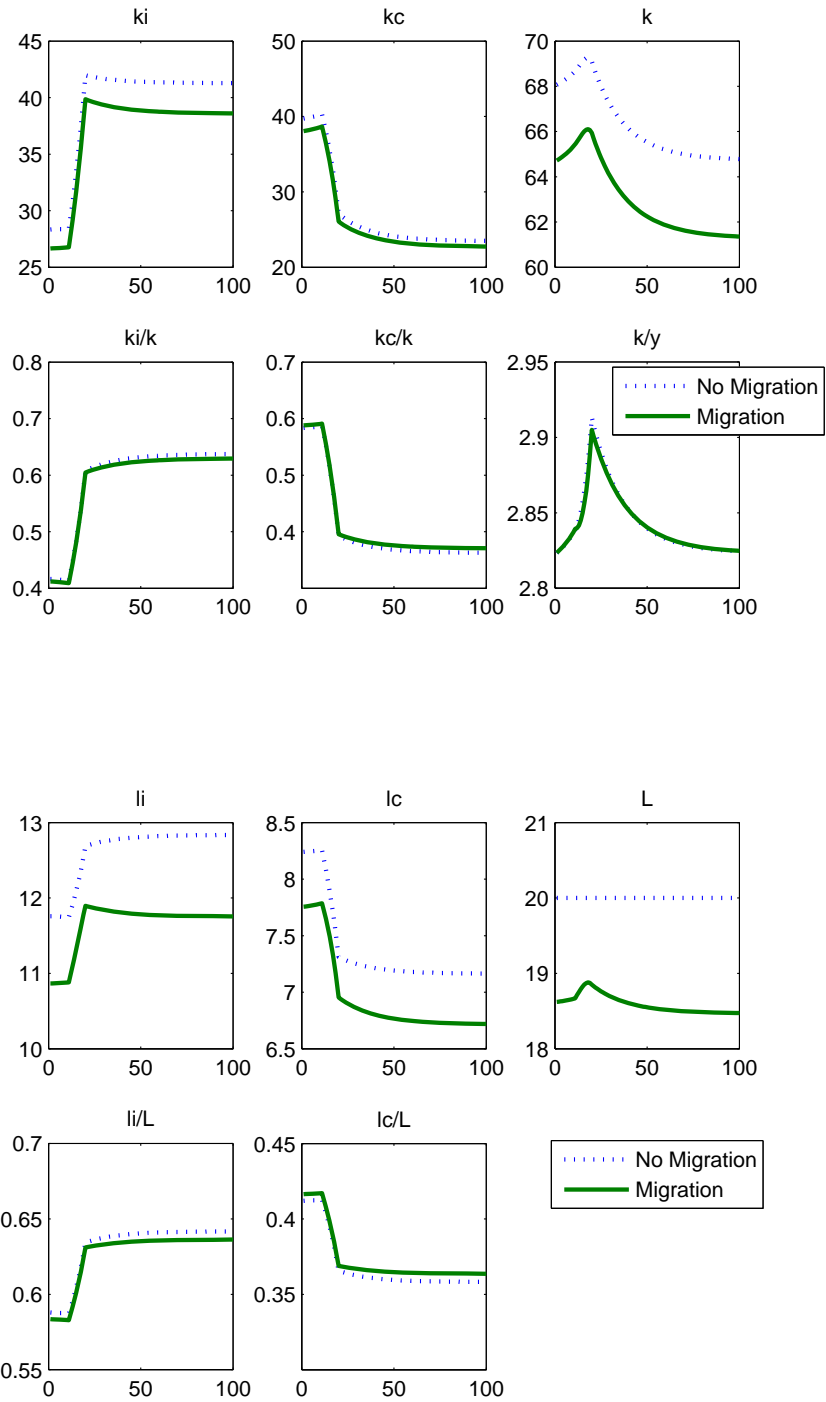
Appendix B

We examine the long run impact of the distortionary government policy here.

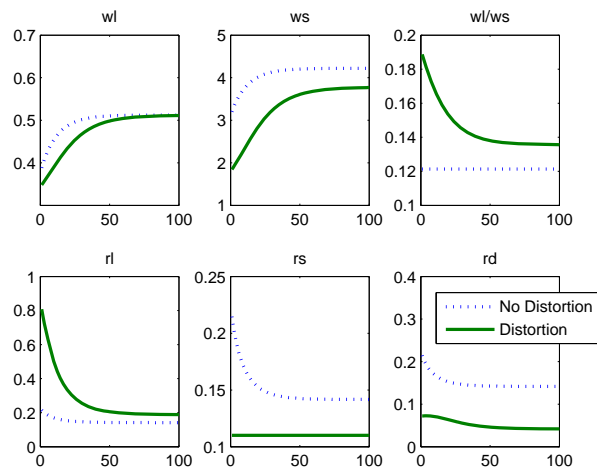## .1 Transition Dynamics without Migration

We start from an initial state where capital is only half of the steady state capital level. The graphs below shows the transitional dynamics for economies with and without distortions. With distortion in the capital market, the social welfare is lower. Welfare is -1.59 without distortion and -2.01 with distortion. In general, economy without distortion reaches a high level of consumption and output.
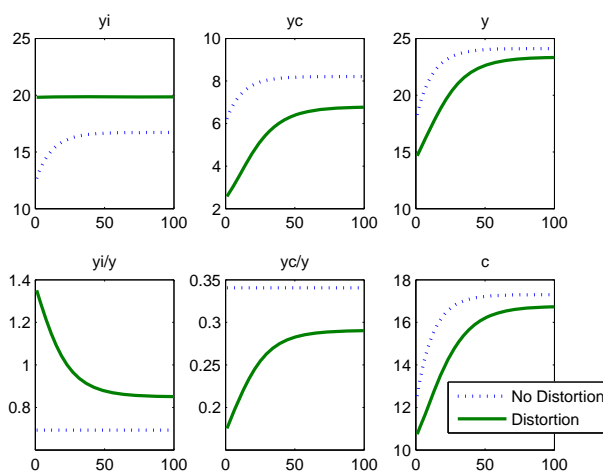
Capital and Labor Allocation   With government policy distortion, infrastructure sector enjoys a low interest rate. Therefore, given the same level of initial capital stock, relatively more capital is allocated to the infrastructure sector compared to the case without any distortion. This happens for the entire transition process because the interest rate distortion is permanent. As capital is accumulated in the economy along time, the market interest rate r_l becomes lower and hence the interest rate premium between the government rate r_S and r_l is smaller. Capital will be reallocated from the infrastructure sector to the consumption sector. Unskilled labor allocation between the two sectors follows a similar pattern.
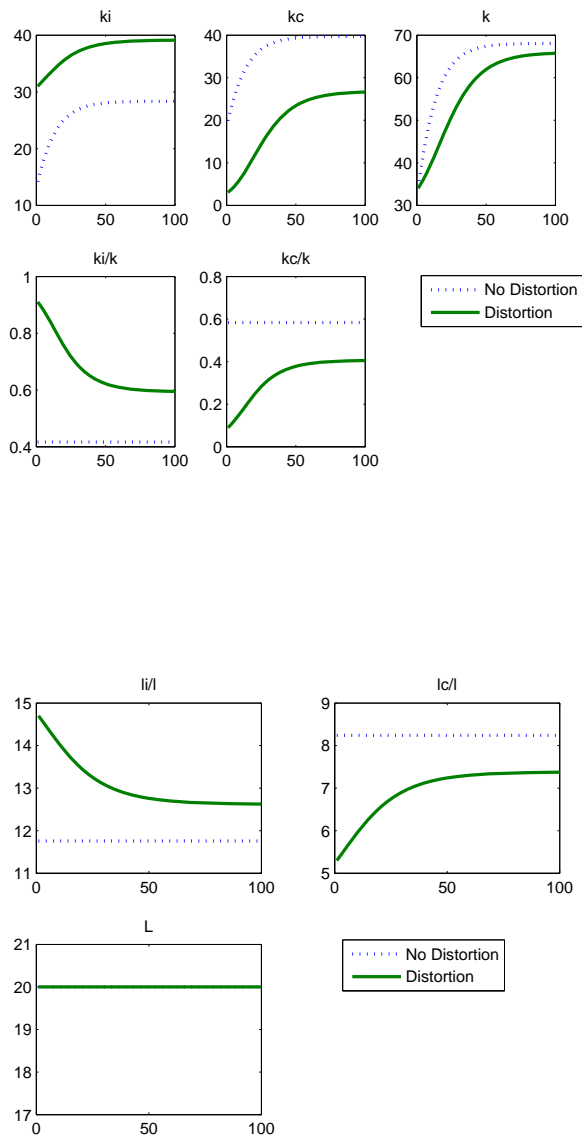
Factor Prices The wage premium is increasing for the distortionary economy as it approaches steady state. This is also caused by the reallocation of resources across sectors. As consumption sector expands, demand for skilled labor increases which drives up the wage for skilled labor and hence put a upward pressure on the wage premium.
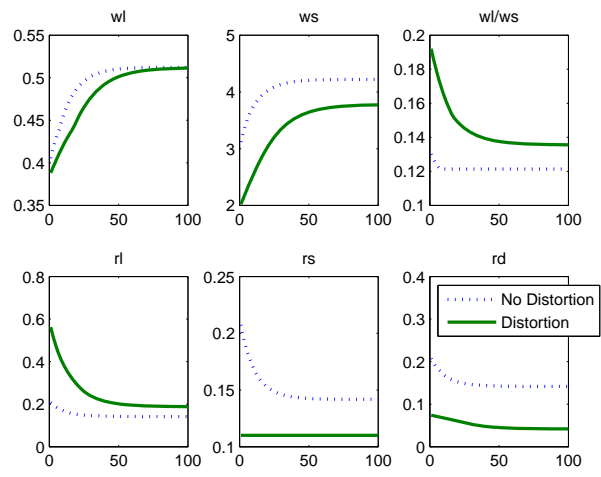
.2   Transition Dynamics with Migration

Under above parameter values, the modeling economy produces 18 periods of migration. We show that the key variables present the similar pattern as those in the economy without migration.
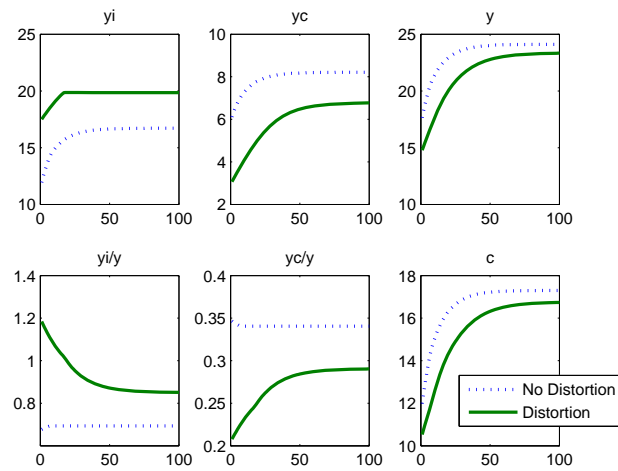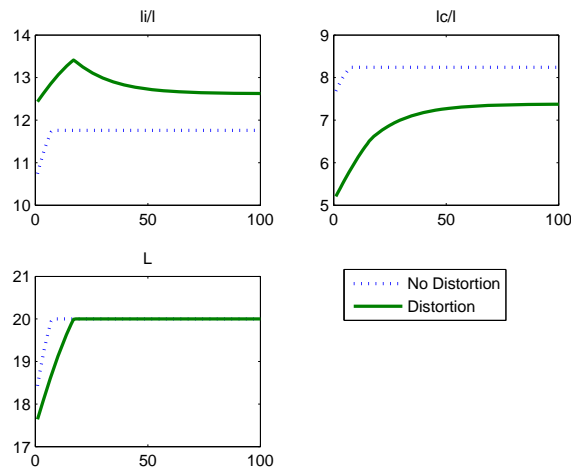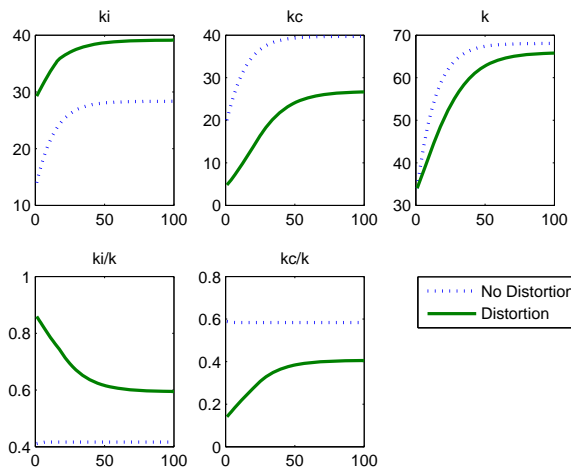
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