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Demographics and FDI: Lessons from China's One-Child Policy[*]

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Abstract

Following the introduction of the one-child policy in China, the capital-labor (K/L) ratio of China increased relative to that of India, and, simultaneously, FDI inflows relative to GDP for China versus India declined. These observations are explained in the context of a simple neoclassical OLG paradigm. The adjustment mechanism works as follows: the reduction in the growth rate of the (urban) labor force due to the one-child policy permanently increases the *capital per worker* inherited from the previous generation. The resulting increase in China's (domestic K)/L thus 'crowds out' the need for FDI in China relative to India. Our paper is a contribution to the nascent literature exploring demographic transitions and their effects on FDI flows.

Keywords: Lucas paradox, capital-labor ratio, FDI-intensity, one-child policy

JEL classification: F11, F21, J11, O11, E13

1. Introduction

This paper explores the influence of population dynamics on relative foreign direct investment (FDI) flows. We contrast China's 1982 mandatory one-child policy decree with India, which initiated a voluntary, but ineffective two-child population control program. Viewing the former as the test case and the latter as the control in a natural experiment, we compare macroeconomic data from the two countries post 1982. We find that the FDI/GDP ratio has been increasing in both countries but declining in China relative to India.[1] We show these observations to be consistent with a neoclassical adjustment process by replicating them in a two-country and 'rest of the world' (ROW) overlapping generations (OLG) model.

The key mechanism in the analysis arises from differential future population growth rates and, in particular, a sudden, exogenous relative decline in the population growth rate of one of the two countries. As such, in every generation the national savings of the older age-cohort in the country with declining population growth accrues to a significantly smaller younger generation, leading to a comparatively higher capital-labor ratio in that country. This leads to relatively lower capital returns, thereby discouraging FDI flows into that country. Two institutional arrangements are key to this result:

1. Home bias in investment financing: in either country investment financing needs are first satisfied using domestically generated savings with FDI covering any shortfall. Indeed, emerging markets economies are usually characterized by a shortage of domestic investment capital with FDI partially making up the shortfall.

2. Individual savings rates are unaffected by fertility: the opportunity to allocate bequest wealth over fewer progeny does not diminish household wealth

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[1] See Figures 3 and 4 to follow.

> accumulation, suggesting that other social phenomena have a dominant role to play in the determination of the household savings rate.[2] Indeed, the literature focused on the impact of China's one-child policy on its national savings rate identifies an enormous increase in China's savings rate following the one-child policy implementation (Choukhmane et al. (2017)).

Various papers offer different explanations for this savings increase, all of a social nature. Curtis et al. (2015) and Choukhmane (2017) hypothesize that reduced fertility implies fewer children to support parents in their old age, thereby inducing parents to increase their own savings. Wei and Zhang (2011) explain the increased savings rate as a competitive response to the policy-induced sex ratio imbalance: families save more to increase the wealth of their sons in order to enhance their position in the competition for increasingly scarce spouses. Imrohoroglu and Zhao (2018) emphasize the long-term care insurance traditionally provided by families, and how the one-child policy has decreased the ability of families to provide it. Parents are thus forced to self-insure and do so by saving more. Other relevant work includes Chamon and Prasad (2010) and Yang et al. (2013). That the savings rate has increased in China only strengthens the mechanism of this paper. More precisely, the mechanism only requires that any savings decline due to reduced fertility does not exceed the rate at which the capital stock per young worker increases.

If capital adjustment costs are present, a model feature we adopt, the same relative FDI patterns are observed, but over the course of a longer time interval. This does not, however, alter the nature of the essential mechanism in any way. In addition, and consistent with the model's implications, we document that the trajectory of the capital stock growth differences between China and India closely track the differences in their respective population growth

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[2] See, e.g. Constantinides et al. (2007).

rates.

This paper is also related to the seminal work of Lucas (1990) which argues that the neoclassical adjustment process (capital flowing to its highest rate of return use) fails to explain the relative paucity of foreign direct investment inflows to poor countries from rich ones, compared to flows among rich countries themselves, where “rich” and “poor” refer to countries with high and low capital-labor ratios.[3] While our results are not in contradiction to Lucas (1990), they do suggest that demographic factors may have important consequences in determining FDI flows.

In summary, the broad message of the paper is two-fold. First, relative population dynamics play a first order role in determining relative cross-country FDI flows. Second, accounting for these flow dynamics suggests that the post-1982 macroeconomic observations from India and China are consistent with underlying neoclassical fundamentals.

An outline of the paper is as follows. Section 2 documents the relative population dynamics and FDI flows for India and China post China’s implementation of its one child policy. Sections 3 and 4 present a parsimonious neoclassical international investment model, the implications of which are shown to replicate the patterns found in the data. Section 5 concludes.

2. Comparative population policies and macroeconomic dynamics in China and India

2.1 Comparative population policies and dynamics

The two countries with the largest populations in the world, China and India, offer a unique contrast regarding population policy. Both countries initiated public policies to control

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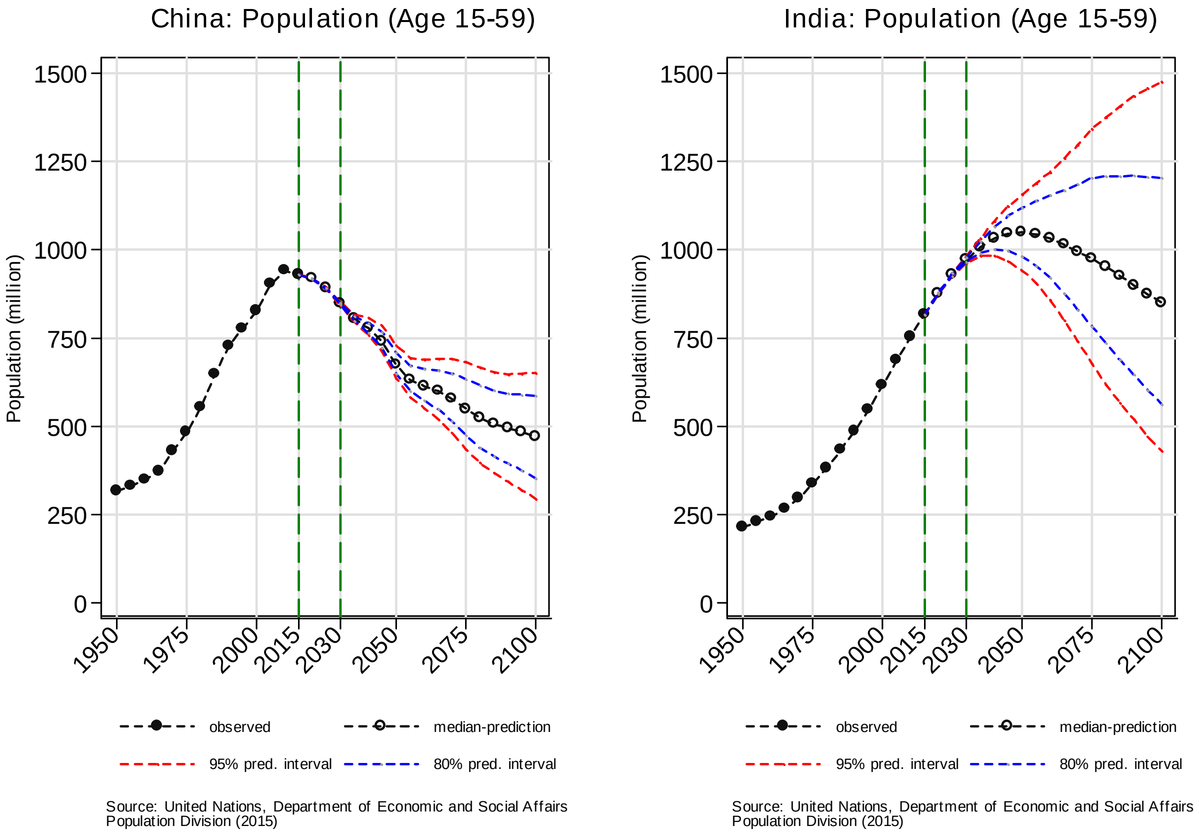
[3] Alfaro et al. (2008, Figure 1, p. 352) support the Lucas (1990) paradox, using data from 23 developed and 75 developing countries.

population growth. In India a two-child birth regulation policy was voluntary and ineffective. In contrast, China's one-child policy was mandatory and effective.


China: Population (Age 15-59)

India: Population (Age 15-59)

Source: United Nations, Department of Economic and Social Affairs
Population Division (2015)

Source: United Nations, Department of Economic and Social Affairs
Population Division (2015)

Figure 1 – Population dynamics in China and India. The two green perpendicular lines indicate that, until 2030, predictions of working population dynamics are robust to any realistic population-growth scenario.

Figure 1 illustrates this major exogenous demographic policy intervention. It depicts actual and predicted population dynamics based on various population growth scenarios with confidence intervals obtained through a Bayesian averaging method.[4] Three key observations result:

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[4] Both data and population projection scenarios in Figure 1 are obtained from the United Nations Population division. Computations are done using an open source package described in Raftery et al. (2012) and Gerland et al. (2014).

1. In China, an absolute decline in the working population (aged 15-59) began in 2010 and is predicted to continue under all reasonable scenarios.[5]
2. With a high degree of confidence, the working population in India is projected to continue increasing at least until 2030.
3. After 2025, the working-aged population in India is projected to exceed that of China.

Figure 1 clearly demonstrates that China's policy intervention was not only effective almost immediately after implementation, in contrast to India's, but also its effects on population dynamics are expected to persist beyond one generation.[6] The anticipation of these persistent policy effects is crucial for investment decisions because investors are forward-looking and major investments are typically long-lived. The combination of contemporaneous and expected future effects of the one-child policy on these comparative population dynamics strengthens the impact of the natural experiment.

2.2 Comparative macroeconomic performance

Table 1 presents comparative growth-performance features, such as productivity growth and GDP growth. These were similar in China and India before and, most especially, after the exogenous demographic intervention, a similarity that allows us to plausibly attribute other trend differences between China and India (e.g., relative FDI flows) solely to China's

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[5] Figure 1 documents a continued increase in China's population for an extended period following the one-child policy initiative. This is due to a gradual increase in policy effectiveness and the gradual elimination of rural exemptions. For the quantity of relevance to the present study, the working population, one would expect a delayed reaction due to schooling and work preparation at least to the age of 16. The model to be proposed captures this decline as occurring in a single 25 year period, which is an artifact of the model's parsimony and the choice of a time interval equivalent to 25 years.

[6] The recently introduced (2017) two-children policy in China may alter the anticipated population dynamics in China, depicted in the left panel of Figure 1, after 2030. Nevertheless, predictions about population dynamics 15 years ahead will not be affected. These predictions are captured later in the time interval bracketed by the vertical dashed lines.

exogenous demographic intervention.

Both China and India experienced very similar rapid GDP growth in the post implementation (1982-2014) period (see the two columns under "g_Y" in Table 1).[7] Note that labor productivity growth was also similar in China and India both in Period 1, and even more so in Period 2 while increasing in both.[8] The capital stock grew more rapidly in China in the latter period, while the dramatic labor force growth slowdown in China is clearly evident in the "g_L" column.

Table 1 Growth rates of macro aggregates. Annual rates (%).

	(i) g_L growth rate of labor		*(ii)* g_K growth rate of capital		*(iii)* g_Y growth rate of GDP		*(iv)* g_A labor productivity growth	
	China	India	China	India	China	India	China	India
Period 1 (1960-1981)	2.05	2.27	7.89	3.52	5.11	4.14	1.69	2.17
Period 2 (1982-2014)	0.82	1.99	13.97	12.42	9.14	9.28	5.94	5.74

Source: Penn World Tables and United Nations.

Data as far back as the 1960s and 1970s is presented for comparison purposes only. Both China and India instituted market economy reforms in 1992. Our competitive model, to be detailed in Sections 3 and 4, thus provides insights only for the post 1992 period.

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[7] For the calculations in Table 1 and the subsequent theoretical analysis, we employ a Cobb-Douglas production function given by $Y_t = K_t^{\alpha} (A_t L_t)^{1-\alpha}$, where Y is GDP, K is capital, L is labor, and A is labor productivity (K is measured as the value of the capital stock and L as total hours worked). The two columns of Table 1 under "g_A", labor productivity growth, have been calculated using the formula $g_A = (g_Y - \alpha g_K) / (1-\alpha) - g_L$ (we have assumed that the capital intensity parameter, $\alpha = 1/3$ in both China and India).

[8] The similarities in productivity differences between China and India are also supported by Hsieh and Klenow (2009), and Bollard, Klenow and Sharma (2013).

Let $\Delta g_{x,t} \equiv g_{x,1,t} - g_{x,2,t}$, with country 1 being China and country 2 being India. Figure 2 plots the empirical $\Delta g_{L,t}$ (red line with boxes) and $\Delta g_{K,t}$ (blue line with circles), and identifies the date when the one-child policy was implemented (1982). Solid lines are the Hodrick-Prescott filtered series. Shortly after 1982, $\Delta g_{L,t}$ assumes negative values which persist (right axis in Figure 2), demonstrating that there has been a strong exogenous demographic intervention in China relative to India.

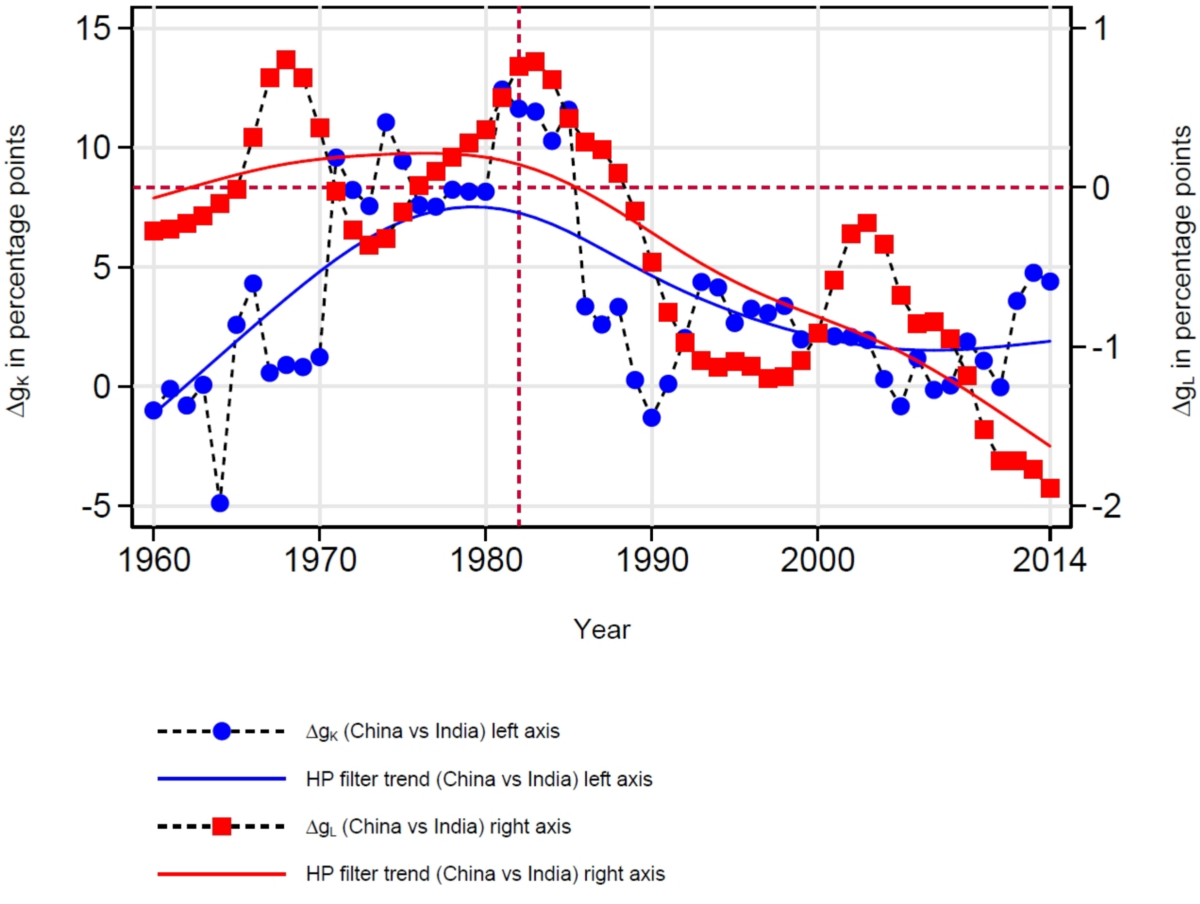

Figure 2 - Differential growth rates of capital and labor: China vs India.

A key feature of Figure 2 is the simultaneous reversal of the $\Delta g_{L,t}$ and $\Delta g_{K,t}$ trajectories. It supports our hypothesis that China's exogenous demographic intervention has played a substantial role in explaining the differential capital-accumulation dynamics in the two countries post 1982.

The fact that $\Delta g_{K,t}$ is positive after 1982 the demographic intervention is not surprising, as Δg_A rose from -0.48% before 1982 to 0.20% after 1982 (see Table 1). This rise in Δg_A is not, however, strong enough to mask the impact of differential population growth on capital growth: $\Delta g_{K,t}$, while positive, is in general decline post 1982.

2.3 Comparative K/L and FDI dynamics

Figure 3 portrays the time path of the FDI/GDP ratio for both China and India post China's demographic intervention.

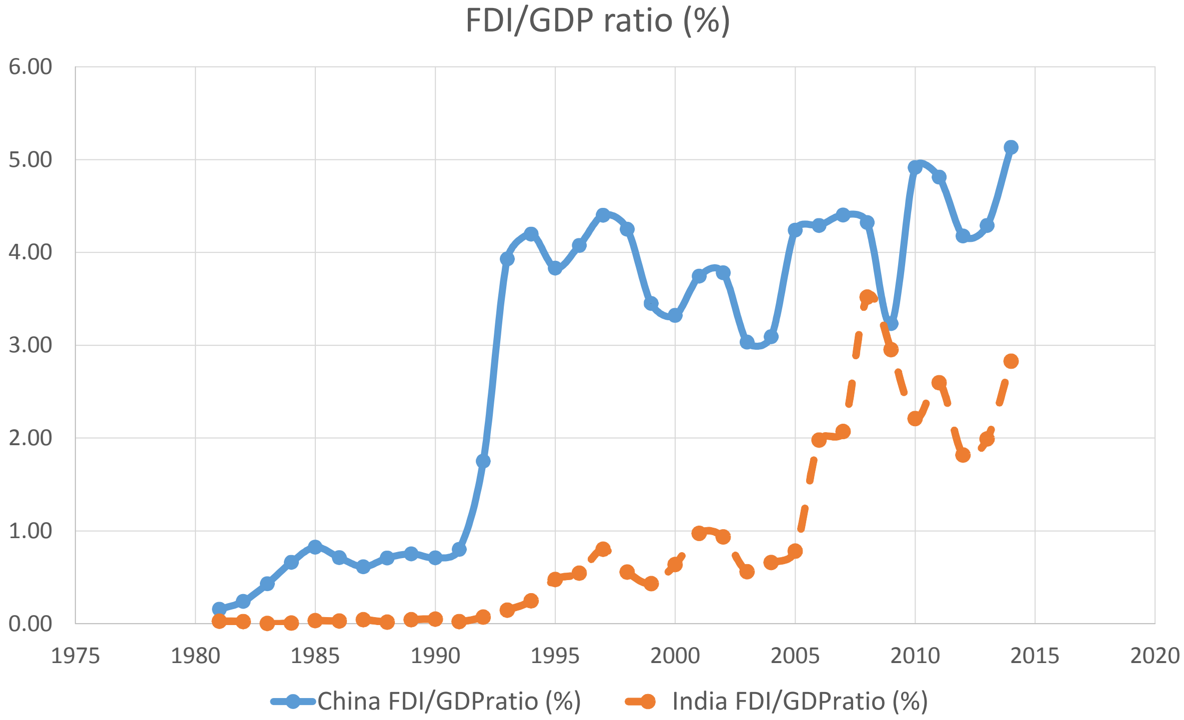

Figure 3 - FDI/GDP ratio in China and India

While China's FDI/GDP ratio persistently exceeds India's it is evident that the gap is, on average, gradually narrowing. This 'catch-up' effect is more evident in the time path of the $\log((\text{FDI/GDP})_{\text{China}}/(\text{FDI/GDP})_{\text{India}})$, as presented in Figure 4.[9] Note that the FDI/GDP

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[9] The data underlying Figures 3 and 4 is in Table A.1 of Online Appendix C.

ratio in both countries was extremely low at the start of the historical period, almost trivially so in the case of India.[10]

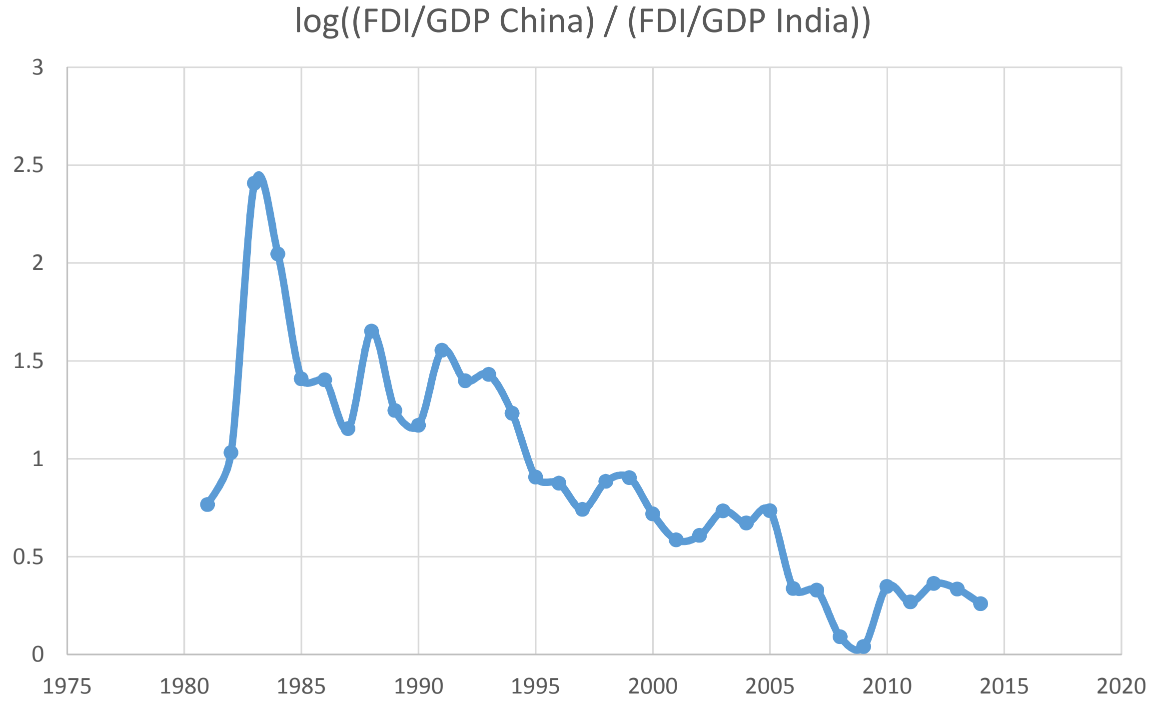

Figure 4 - Time path of $\log((\text{FDI/GDP})_{\text{China}}/(\text{FDI/GDP})_{\text{India}})$

While neither country has experienced a monotonic increase in its historical FDI/GDP ratio, the ratio in both is presently quite high, roughly in the range of 3% to 5% (Figure 3). By comparison, the analogous ratio for the USA in 2017 was a negligible 0.033%.[11]

We next turn to the relative growth rates, China vs. India, as regards capital per worker (K/L) and FDI as a share of GDP for the period surrounding 1982. These are presented in Figure 5.

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[10] For example, India's FDI/GDP ratio in 1983 was 0.002%.

[11] For 2017, the U.S. Bureau of Economic Analysis (BEA) lists FDI into the USA in the categories "establish new US businesses" and "expand existing foreign-owned businesses" as respectively $4.1 billion and $2.4 billion, as compared to a 2017 GDP of $19.485 trillion (BEA News, July 11, 2018).

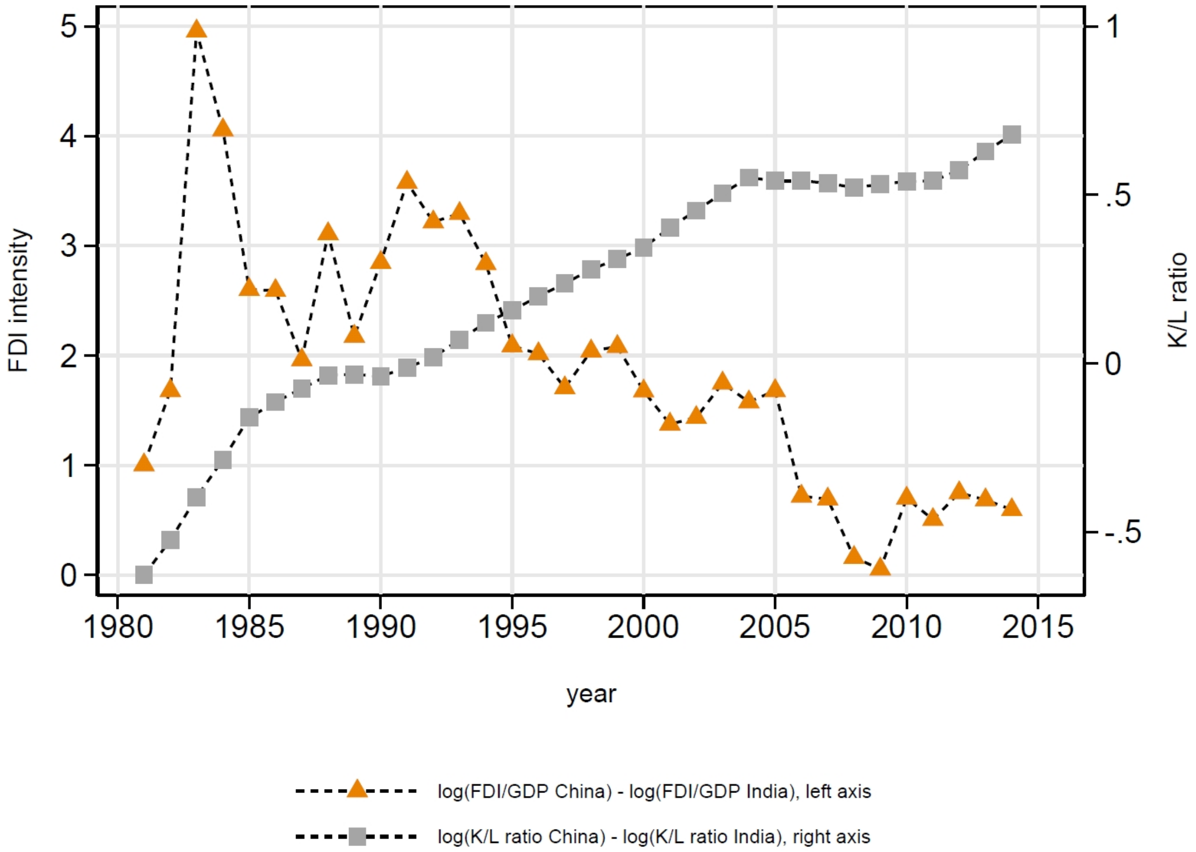

Figure 5 - Differential growth rates of FDI/GDP and K/L: China vs India.

After the demographic intervention, the K/L ratio of China grew more rapidly than that of India. During the same period, FDI intensity (measured by FDI as a share of GDP) grew faster in India than in China. In 1990, the intensity of FDI in China was about 30 times larger than that of India, but by 2014, the intensity of FDI in China was less than 2 times that of India.[12] In the remainder of this paper we provide a model to rationalize these

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[12] In Online Appendix C we document the data used in Figure 5 and offer a robustness check focusing on K/L trends of the non-agricultural workforce in both countries (see Figure A.6 and Table A.2 in Online Appendix C). It is important to note that FDI in China and India during the period examined did not represent the purchase of existing domestic capital by foreign entities; observed FDI data predominantly describes the formation of new capital. This experience contrasts with that of the US where the vast majority of FDI is for the purchase of claims to already existing capital stock.

observations.

3. The Model

We construct a parsimonious OLG model of two countries, 1 and 2, and the rest of the world (ROW). We assume that countries 1 and 2 are price takers in international capital markets, where the 'world interest rate', denoted by r^*, is constant. For simplicity, we elect to focus on FDI flows from ROW to these two countries. Other key simplifying assumptions are:

- Capital flows from ROW to countries 1 and 2, but there are no capital flows between countries 1 and 2.
- The labor force of each country cannot move to the other country.
- There is no international trade in final goods.[13]

None of these assumptions is crucial to the model's implications.

3.1 Production

Aggregate domestic production in country $i \in \{1, 2\}$ in period t is characterized by the production technology,

$$Y_{i,t} = Y_{i,t}^{i} + Y_{i,t}^{r} \ , \tag{1}$$

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[13] This is a simplifying assumption, following Backus, Kehoe, and Kydland (1992) and Holmes, McGrattan and Prescott (2015). While there are plausible reasons to assume that FDI may be more focused on selling in a local market rather than as a base for exports (see the discussion in Holmes, McGrattan and Prescott, 2015, p. 1159), this assumption is not critical for the qualitative conclusions implied by the model. Assuming a fully integrated final-goods market would add more arbitrage conditions but would not eliminate the key arbitrage conditions behind the K/L ratio dynamics studied here. Our empirical application focuses on China and India, two countries that have, historically, faced both geographical and political barriers to capital flows and trade.

where,

$$Y_{i,t}^{i} = \left(K_{i,t}^{i}\right)^{\alpha_i} \left(A_{i,t}^{i} L_{i,t}^{i}\right)^{1-\alpha_i} \quad , \qquad \alpha_i \in (0,1) \tag{2}$$

and

$$Y_{i,t}^{r} = \left(FDI_{i,t}^{r}\right)^{\alpha_i} \left(A_{i,t}^{r} L_{i,t}^{r}\right)^{1-\alpha_i} \quad . \tag{3}$$

Subscripts denote the location of productive activity and superscripts denote the investing country. Specifically, $K_{i,t}^{i}$ is the period t capital of country i invested by domestic firms, while $FDI_{i,t}^{r}$ is the stock of FDI capital invested by ROW firms in country i. $L_{i,t}^{i}$ is the part of the workforce of country i working in firms using capital financed by country i, while $L_{i,t}^{r}$ denotes workers of country i that work for ROW companies using FDI. The common depreciation rate for capital $K_{i,t}^{i}$ and $FDI_{i,t}^{r}$ is $\delta \in (0,1]$, for $i \in \{1,2\}$. The exogenous labor productivity levels in the two sectors are denoted by $A_{i,t}^{i}$ and $A_{i,t}^{r}$, a distinction that allows productivity growth to be either location-specific or firm-specific. Factors such as the extent of bureaucracy, infrastructure, political instability, etc., may cause the productivity of a foreign firm to be location-specific. Furthermore, technology transfer (as, e.g., in Holmes, McGrattan and Prescott, 2015), which we do not explicitly model, could cause productivity to be firm-specific. In each country i, we postulate a large number of identical firms operating the technologies described by equations (2) and (3).

Based on the assumption of no cross country labor force mobility, and assuming full employment in each country,

$$L_{i,t} = L_{i,t}^{i} + L_{i,t}^{r} \ , \tag{4}$$

where $L_{i,t}$ is the total workforce (population) in country $i \in \{1,2\}$. We assume that population growth is exogenously given by,

$$\frac{L_{i,t+1}}{L_{i,t}} = e^{g_{L,i,t+1}} \ , \ \ t = 0,1,\dots \ . \tag{5}$$

Our production structure is a simplified version of the one in McGrattan and Prescott (2009, 2010) and Holmes et al. (2015), with some modifications to the role of labor in production.[14]

3.2 Efficient factor allocation

The representative firm, i or r, located in country $i \in \{1, 2\}$, is profit maximizing in an environment of perfectly-competitive factor markets. Accordingly, factor demands are driven by equating marginal products to factor prices. In addition, since firm production functions exhibit constant returns to scale and factor flows within a country are frictionless, the competitive equilibrium efficiently allocates factor inputs $\left(K^i_{i,t}, FDI^r_{i,t}, L^i_{i,t}, L^r_{i,t}\right)$ in each country to maximize domestic production (see also McGrattan and Prescott, 2009, 2010).

The intra-temporal conditions for the efficient allocation of factor inputs, $\left(K^i_{i,t}, FDI^r_{i,t}, L^i_{i,t}, L^r_{i,t}\right)$, in order to maximize $Y_{i,t}$, subject to,

$$K_{i,t} = K^i_{i,t} + FDI^r_{i,t} \ , \quad \text{and} \quad L_{i,t} = L^i_{i,t} + L^r_{i,t} \ , \tag{6}$$

where $K_{i,t}$ is total country i capital and $L_{i,t}$ total country i labor, are,

$$MPK^i_{i,t} = MPK^r_{i,t} \ , \tag{7}$$

and,

$$MPL^i_{i,t} = MPL^r_{i,t} \ . \tag{8}$$

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[14] The McGrattan and Prescott (2009, 2010) models assume that total population, $L_{i,t}$, enters the production function of both companies relying on domestic capital and of companies relying on FDI. Using the abstractions and notation of our model, domestic production in a McGrattan and Prescott (2009, 2010) type of model would be,

$$Y_{i,t} = \left[\left(K^i_{i,t}\right)^{\alpha_i}\left(A^i_{i,t}\right)^{1-\alpha_i} + \left(K^j_{i,t}\right)^{\alpha_i}\left(A^j_{i,t}\right)^{1-\alpha_i}\right]\left(L_{i,t}\right)^{1-\alpha_i} \ .$$

They motivate their formulation by the observed correlation between population size and FDI-location capacity. The McGrattan and Prescott (2009, 2010) formulation is convenient for obtaining an aggregate Cobb-Douglas domestic-production function. In this paper we suggest company-specific Cobb-Douglas production technologies and clearly distinguish those who work in FDI-related companies and those who work in domestically financed companies.

Here “MPK” and “MPL” signify the marginal product of capital and marginal product of labor respectively.

3.3 Households, domestic savings, and national capital

We use a simple variant of the overlapping-generations (OLG) model developed in Diamond (1965). Individuals live for two periods. Omitting subscript i, unless necessary, the following notation applies:

$c_{1,t}$ $\equiv$ consumption of a young agent born at time t (t specifies the generation)

$c_{2,t}$ $\equiv$ consumption when old at time $t+1$ of an individual born at time t

L_t $\equiv$ number of individuals born in period t and working in period t

w_t $\equiv$ competitive wage received in period t

r_{t+1} $\equiv$ interest rate paid on savings held from period t to period $t+1$.

Aggregate consumption in period $t+1$ is thus $L_t \cdot c_{2,t} + L_{t+1} \cdot c_{1,t+1}$ (see below)

		Periods			
		t	$t+1$	$t+2$	$t+3$
Age	**born in** t	$c_{1,t}$	$c_{2,t}$		
Groups	**born in** $t+1$		$c_{1,t+1}$	$c_{2,t+1}$	
	born in $t+2$			$c_{1,t+2}$	$c_{2,t+2}$
	aggregating		$L_t \cdot c_{2,t}+$	$L_{t+1} \cdot c_{2,t+1}+$	
			$L_{t+1} \cdot c_{1,t+1}$	$L_{t+2} \cdot c_{1,t+2}$	

We further assume:

1. Within each cohort, individuals are identical. The utility function of a representative individual is given by,

$$U\left(c_{1,t}, c_{2,t}\right) = \log\left(c_{1,t}\right) + \beta \log\left(c_{2,t}\right), \text{ with discount factor } \quad \beta \in (0,1) \ . \tag{9}$$

2. Labor supply is completely inelastic and equal to one unit per period. Accordingly, the labor income of an individual when working in period t is w_t.

3. When young, individuals work, consume and accumulate capital (save). When old, individuals rent their capital to firms (in which the young generation works), consume, and die.

The consumption of generation t, when old (occurring in period $t+1$), is thus given by,

$$c_{2,t} = \left(1 + r_{t+1}\right) s_t \ , \tag{10}$$

where s_t denotes period t savings of a household (when young). Since the only source of income when young is the wage income w_t, $s_t = w_t - c_{1,t}$, and (10) becomes,

$$c_{1,t} + \frac{c_{2,t}}{1 + r_{t+1}} = w_t \ . \tag{11}$$

Maximizing lifetime utility (9) subject to the lifetime constraint (11) yields,

$$s_t = \frac{\beta}{1+\beta} w_t \ . \tag{12}$$

Aggregate domestic savings of the young generation, $S_{i,t} = s_{i,t} L_{i,t}$, is equal to aggregate investment, which augments the national capital stock of the country in period t. Equation (12) then implies,

$$K_{i,t}^{i} = (1-\delta) K_{i,t-1}^{i} + \underbrace{\frac{\beta_i}{1+\beta_i} w_{i,t-1} L_{i,t-1}}_{\overset{\shortparallel}{S_{i,t-1}}} \ , \quad i \in \{1,2\} \ . \tag{13}$$

Under one additional assumption,

$$A^i_{i,t} = A^r_{i,t} = A_{i,t} \ , \ \ t = 0, 1, ..., \tag{14}$$

production in both countries $i \in \{1, 2\}$ is given by an aggregated domestic production function of the form,

$$Y_{i,t} = K^{\alpha_i}_{i,t} \left(A_{i,t} L_{i,t}\right)^{1-\alpha_i} = \left(K^i_{i,t} + FDI^r_{i,t}\right)^{\alpha_i} \left(A_{i,t} L_{i,t}\right)^{1-\alpha_i} \ . \tag{15}$$

This special case allows the derivation of analytical results with direct empirical implications. Nevertheless, assuming $A^i_{i,t} \neq A^j_{i,t}$*, and* $A^j_{j,t} \neq A^i_{j,t}$*, gives the same empirical implications as described below, while depriving us of certain simplifying formulae that follow later in the paper. In what follows, we thus maintain assumption (14).*[15] See Online Appendix A for the derivation of expression (15).

Although we make assumptions (namely logarithmic preferences) that lead to a constant savings rate, all of our qualitative results and testable implications are preserved if the savings rate is increasing through time. The mechanism on which this paper is based is one where the declining population means that each generation provides the next with higher capital per worker, a fact that discourages/crowds-out FDI flows.[16] An increased savings rate would only reinforce the phenomenon we emphasize. Indeed, from 1980-2010 the household savings rate in China doubled (see, e.g., Imrohoroglu and Zhao, 2018).

3.4 Capital adjustment costs

In the absence of any capital adjustment cost, optimal investment is governed by,

$$r^* + \delta = MPK_{i,t} \ , \quad i \in \{1, 2\} \ . \tag{16}$$

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[15] We also assume that $A^i_{i,t} = A^r_{i,t}$ because we lack any data on labor productivity growth in foreign owned vs. domestically owned firms.

[16] The expression 'crowding out' implies that the lower capital returns which follow on higher K/L ratios reduce the incentives for foreign firms to undertake FDI.

With frictionless capital flows and unlimited capital availability at the world cost of capital r^*, steady state transitions due to underlying parameter changes will occur in one period which, in this model, corresponds to one-half of an adult lifetime. In order to better match the empirical duration of transitions we impose a capital adjustment cost on the dynamics implied by equations (13) and (16). In particular, we modify equation (16) to be of the form:

$$r^* + \delta = MPK_{i,t} + \psi\left(t, \bar{t}\right) \ , \quad i \in \{1, 2\} \ , \tag{17}$$

where,

$$\psi\left(t, \bar{t}\right) = \begin{cases} 0 & , \quad \text{if } \ t \leq \bar{t} \\ \eta \cdot (1-\chi)^{t-\bar{t}-1} & , \quad \text{if } \ \bar{t} + 1 \leq t \end{cases} \ , \tag{18}$$

where $\eta > 0$, $\chi \in (0, 1)$.[17] The symbol $\bar{t} > 0$ denotes the period in which an exogenous intervention shocks the equilibrium away from its steady-state path. For some periods after a transitional shock there is a loss of $\eta \cdot (1-\chi)^{t-\bar{t}-1}$ in capital returns, which we postulate as due to some combination of industrial relocation costs and institutional adjustment costs such as bureaucratic frictions.[18] These institutional adjustments are gradually smoothed out, and the capital-returns wedge, $\eta \cdot (1-\chi)^{t-\bar{t}-1}$, decays over time at rate χ.

3.5 Equilibrium

Equilibrium is characterized by a set of prices and quantities at which all firms maximize profits, all households maximize utility as price takers given these equilibrium prices and all

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[17] Note that equation (17) assumes a constant return on capital worldwide and in the countries under study. A large literature has developed seeking to explain China's high and stable return on capital of around 20% in conjunction with the high savings rate (see Bai et al., 2006, and Song et al. 2011). India's return on capital is difficult to estimate since much of it is held in non-financial assets.

[18] The exogenous wedge that we impose upon condition (16) through equations (17) and (18) is similar to measured wedges that reflect deviations from the covered interest rate parity condition observed by Du, Tepper, and Verdelhan (2017) after the recent financial crisis. Du, Tepper, and Verdelhan (2017) attribute these deviations to costs associated with bank regulation. They can be seen as adjustment costs of moving from pre-crisis to post-crisis leverage ratios. For some countries, these covered interest rate parity deviations were stronger during the financial crisis crisis and then started fading away over time, as equation (18) implies (Du, Tepper, and Verdelhan, 2017, Figure 2).

domestic and international markets clear at these equilibrium prices and quantities.

In the model with adjustment costs, equilibrium in country $i \in \{1, 2\}$ is characterized by conditions (13) and (17), with adjustment costs introducing long-lasting transitions in the capital labor ratio. In a steady state, adjustment costs are zero by construction.

In the next sections we study the effects of an exogenous demographic intervention on the equilibrium K/L ratio and FDI. The intervention is characterized by a sudden decrease in population growth in one of the two countries, similar to what occurred after the introduction of the one-child policy in China. This intervention puts a country in a transition characterized by changes in its K/L ratio and FDI flows. Specifically, following a drop in population growth, momentum in capital dynamics, exaggerated by capital-adjustment costs, increases the K/L ratio, which leads to a drop in the marginal product of capital, that, in turn, discourages FDI inflows.

To analyze these effects in detail, we rely on specific relationships describing K/L ratio dynamics both along the transition path toward the steady-state growth path, and along the steady state growth path itself. These are presented below:

a) Transition Dynamics

Equation (17) implies,

$$\frac{K_{i,t}}{A_{i,t}L_{i,t}} = \left[\frac{\alpha_i}{r^* + \delta - \psi\left(t, \bar{t}\right)}\right]^{\frac{1}{1-\alpha_i}} . \tag{19}$$

In turn, equation (19) implies that the growth rates of capital, labor and labor productivity are jointly related according to

$$g_{K,i,t} \equiv \ln\left(K_{i,t}\right) - \ln\left(K_{i,t-1}\right) = \frac{1}{1-\alpha_i} \ln\left[\frac{r^* + \delta - \psi\left(t-1, \bar{t}\right)}{r^* + \delta - \psi\left(t, \bar{t}\right)}\right] + g_{A,i,t} + g_{L,i,t} . \tag{20}$$

From equation (20) we see that an exogenous demographic intervention that reduces population growth from a constant rate $g_{L,i}$ to a lower constant rate $\bar{g}_{L,i}$, will also cause a drop in the growth rate of domestic capital, absent changes in labor productivity growth.

b) Steady State Growth Dynamics ($\psi(t,\bar{t})=0$)

We maintain our assumption that population growth is constant and further assume that productivity growth is also constant over time in country $i \in \{1,2\}$, i.e.,

$$\frac{L_{i,t+1}}{L_{i,t}} = e^{g_{L,i}} \ , \ \ \frac{A_{i,t+1}}{A_{i,t}} = e^{g_{A,i}} \ . \tag{21}$$

In conjunction with (17) and (18), equation (15) yields,

$$r^* + \delta = \frac{\partial Y_{i,t}}{\partial K_{i,t}} \ \equiv MPK_{i,t} = MPK^i_{i,t} = MPK^r_{i,t} \ , \ \ i \in \{1,2\} \ . \tag{22}$$

In Online Appendix B we show that the steady state growth path in economy i is characterized by equations,

$$\left(\frac{Y_{i,t}}{L_{i,t}}\right)^{ss} = \left(\frac{\alpha_i}{r^*+\delta}\right)^{\frac{\alpha_i}{1-\alpha_i}} A_{i,t} \ , \tag{23}$$

$$\left(\frac{K^i_{i,t}}{L_{i,t}}\right)^{ss} = \frac{\beta_i\left(1-\alpha_i\right)}{\left(1+\beta_i\right)\left(e^{g_{A,i}+g_{L,i}}+\delta-1\right)}\left(\frac{\alpha_i}{r^*+\delta}\right)^{\frac{\alpha_i}{1-\alpha_i}} A_{i,t} \ \ , \tag{24}$$

and,

$$\left(\frac{FDI^r_{i,t}}{Y_{i,t}}\right)^{ss} = \frac{\alpha_i}{r^*+\delta} - \frac{\beta_i\left(1-\alpha_i\right)}{\left(1+\beta_i\right)\left(e^{g_{A,i}+g_{L,i}}+\delta-1\right)} \ . \tag{25}$$

Equation (24) implies that an exogenous demographic intervention that reduces population growth from a constant rate $g_{L,i}$ to lower constant rate $\bar{g}_{L,i}$, will permanently increase national capital per worker. This permanent increase in $\left(K^i_{i,t}/L_{i,t}\right)^{ss}$ reduces capital returns. By equation (25), the crowding out of FDI will also cause a drop in the long run steady-state level of the FDI/GDP ratio.[19] Equations (19) - (25) form the backbone of the analysis to

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[19] Crowding out of FDI arises from the fact that the steady state $\left(K_{i,t}\right)^{ss}/\left(Y_{i,t}\right)^{ss} = \left[\left(K_{i,t}\right)^{ss} + \left(FDI^r_{i,t}\right)^{ss}\right]/\left(Y_{i,t}\right)^{ss} = \alpha_i/\left(r^*+\delta\right)$, and is independent of the growth rate of labor. Accordingly, a reduction in $\left(FDI^r_{i,t}\right)^{ss}/\left(Y_{i,t}\right)^{ss}$ attends an increase in $\left(K_{i,t}\right)^{ss}/\left(Y_{i,t}\right)^{ss}$, amounting to the substitution of domestic capital for foreign capital.

follow. In using these equilibrium relationships we will essentially be exploring transitions between steady states that arise as the result of a fundamental parameter change, a reduction in the population growth rate.

In the next section we replicate the empirical regularities depicted in Section 2 as equilibrium outcomes of the model just detailed when one of the countries experiences a negative shock to its population growth rate.

4. Model Implications

The goal of this paper is to emphasize the role played by the one-child policy in China in explaining the *comparative* FDI/GDP dynamics in China and India. Explaining the precise trajectories of the FDI/GDP levels in China and India, especially the very low FDI/GDP levels of the early 1980s, when neither of the two countries were market economies, is a challenge that requires introducing market and trade wedges, something we eschew. Accordingly, we focus on the post 1990 period, when both China and India displayed robust FDI/GDP ratios and almost free access to international markets. For this period the role of demographics in explaining the comparative FDI trajectories in China and India should be transparent.[20]

In particular, we study a parametrized version of the model where an exogenous demographic intervention occurs in period 10. The length of each period is $T = 25$. The annual rate of time preference is $(1 - \beta)/\beta = 6\%$. The annual labor productivity growth rate is $g_A = 4\%$, a rough average of the data summarized in Table 1. For the treated country, the annual population growth rate prior to the intervention is $g_L = 2\%$, and $\tilde{g}_L = -1\%$ afterwards. For the control country it is 2% throughout. The output elasticity of capital

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[20] As shown in Table 1, the productivity differences between China and India have been very small. This similarity allows us to focus on the comparative effects caused by the exogenous intervention in the population growth rate of China.

is $\alpha = 1/3$, while the value for the annual world interest rate, r^*, is set to $r^* = 3\%$, in accordance with estimates in Holston, Laubach, and Williams (2017). Following Klenow and Rodriguez-Clare (1997, p. 76), the annual depreciation rate, δ, is set to $\delta = 3\%$. The annual wedge on the world capital return is $\eta = 0.5\%$, and the rate of decay of the world-interest rate wedge is $\chi = 30\%$.[21]

4.1 Relative growth in capital and labor

Since India's demographic-control policies were broadly ineffective and it was exposed to the same globalization factors as China (especially in the mid-1990s), we postulate that India remained close to its steady-state path, and examine the difference in the capital growth rate between the two countries. In particular, equation (20) can be re-written as,

$$\Delta g_{K,t} = \frac{1}{1-\alpha_1} \ln \left[\frac{r^* + \delta - \psi\left(t-1, \bar{t}\right)}{r^* + \delta - \psi\left(t, \bar{t}\right)} \right] + \Delta g_{L,t} + \Delta g_{A,t} \ , \tag{26}$$

where $\Delta g_{x,t} \equiv g_{x,1,t} - g_{x,2,t}$. Identifying country 1 as China and country 2 as India, equation (26) relates the relative capital stock growth, China vs. India, to the relative labor force and productivity growth rates.

Consistent with the data in Table 1, we assume $\Delta g_{A,t} = 0$. With $\Delta g_{A,t} = 0$, equation (26) implies a direct positive connection between $\Delta g_{L,t}$ and $\Delta g_{K,t}$ and offers an identification test: if growth dynamics in China and India are governed by the neoclassical production process assumed in equation (15), then the unique demographic intervention in China (the imposition of the one-child policy, a quasi-natural experiment) should be manifest empirically as a simultaneous reversal of the $\Delta g_{K,t}$ and $\Delta g_{L,t}$ trajectories post the intervention. Direct empirical evidence identifying this causal reversal, a drop in $\Delta g_{K,t}$ caused by an exogenous

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[21] Both economies in our analysis share these common parameter values except for g_L which, for the treated country only (China), changes from $g_L = 2\%$ to $\tilde{g}_L = -1\%$.

drop in $\Delta g_{L,t}$, is present in Figure 2.[22]

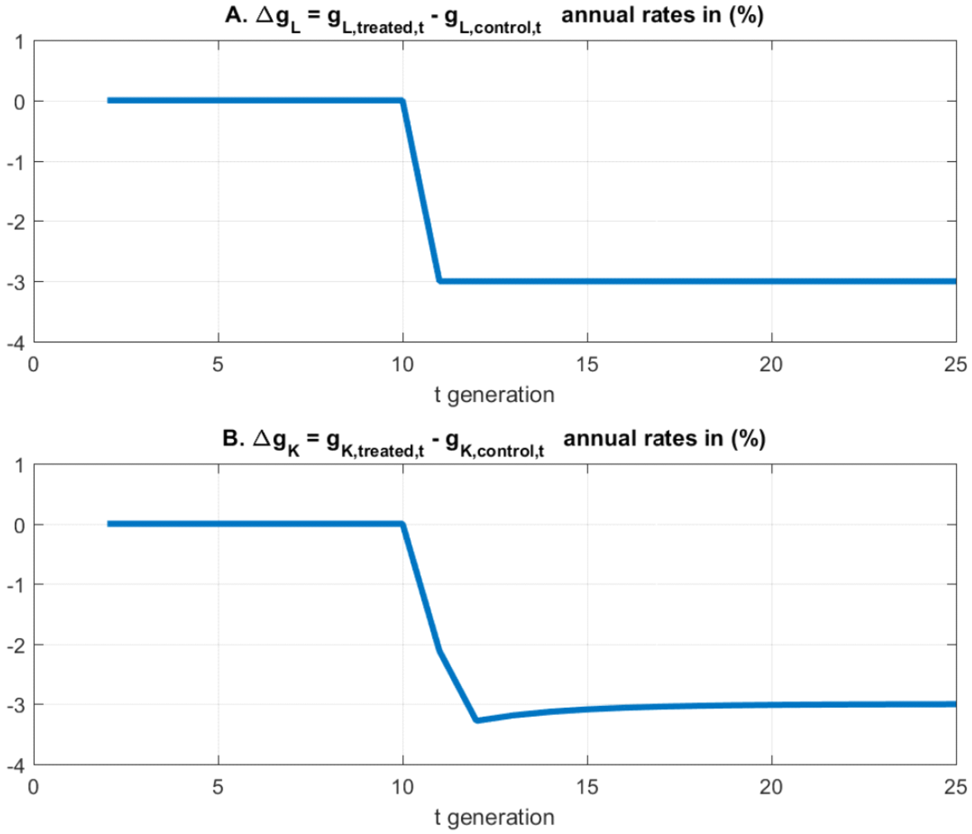

Figure 6 – The effect of demographic intervention on the difference in the capital growth rate for the two economies around the time of the demographic intervention (treatment for one country only).

For the parameter choices above, Figure 6 portrays the indicated corresponding model-generated $\Delta g_{K,t}$ and $\Delta g_{L,t}$ trajectories, prior to and following the noted demographic intervention.[23] Figure 6 confirms that the theoretical model implications depicted in Figure 6

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[22] The observed differences in magnitudes between $\Delta g_{K,t}$ and $\Delta g_{L,t}$ in Figure 2, can be theoretically attributed to the wedge dynamics in equation (26) and empirically to institutional, cultural or other latent factors.

[23] Note that the control country is initially identical to its treated counterpart even with reference to the level of labor productivity.

conform to the empirical observations detailed in Figure 2.

4.2 The impact of an exogenous demographic intervention on relative FDI dynamics

In this section we focus on FDI, specifically the trajectories of capital inflows from ROW. It is assumed that both countries are identical as regards their initial K/L ratio and have identical labor productivity growth rates before and after the intervention.

Using the parameter values detailed in the previous section, Figure 7 depicts model-generated differences between one country experiencing an exogenous period-10 demographic intervention, and a country on its steady-state path. Panels A, C and E describe the consequences for the treated country while Panels B, D and F compare its response to the intervention with the corresponding quantity in the control country.

First consider Panels A and B of Figure 7.[24] Following the demographic intervention, the K/L ratio of the treated country spikes up (Panel A) before returning to its long run steady state value.[25] As a result, the K/L ratio in the treated country increases relative to the control country as captured in Panel B.[26] After some generations, the effect disappears, with the K/L ratio in both countries identical once again (Panel B) as required by their identical productivity growth rates. The K/L ratio effects are directly reflected in the corresponding MPK values: the abrupt increase in the treated country's K/L ratio has its counterpart in an absolute reduction in its MPK (Panel C), and a relative MPK reduction vis-a-vis the control country (Panel D). Following equation (18), adjustment costs of industrial relocation, and

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[24] To assess the implications of Figure 7, the reader is again reminded that if we consider two time series, x_t and z_t, and plot $\log(x_t) - \log(z_t)$ over time, then an upward-sloping $\log(x_t) - \log(z_t)$ implies that x_t grows faster than z_t.

[25] As stressed above, in equation (19), capital in efficiency units, $K/(AL)$, is tied to the world interest rate, r^*. In order to better understand the dynamics of K/L ratios we need to control for changes in the dynamics of labor productivity, A, which we plot in Panel A of Figure 7 as $K/(AL)$.

[26] Following the identification mentioned in the preceding paragraph, the K/L ratio in the treated country grew relative to its equivalent in the control country.

institutional adjustments such as bureaucratic frictions are manifested in a temporary drop in capital returns, driven by the capital-returns wedge, $\psi\left(t,\bar{t}\right)=\eta\cdot\left(1-\chi\right)^{t-\bar{t}-1}$, that decays over time. Our choice of parameter η is an annual rate of 0.5%, and the decay parameter $\chi\ =\ 0.3$ implies that the half-life of this interest-rate wedge η is about 50 years, which corresponds to two generations of young workers (T=25 years). These values of η and χ reproduce empirically plausible K/L ratio dynamics.

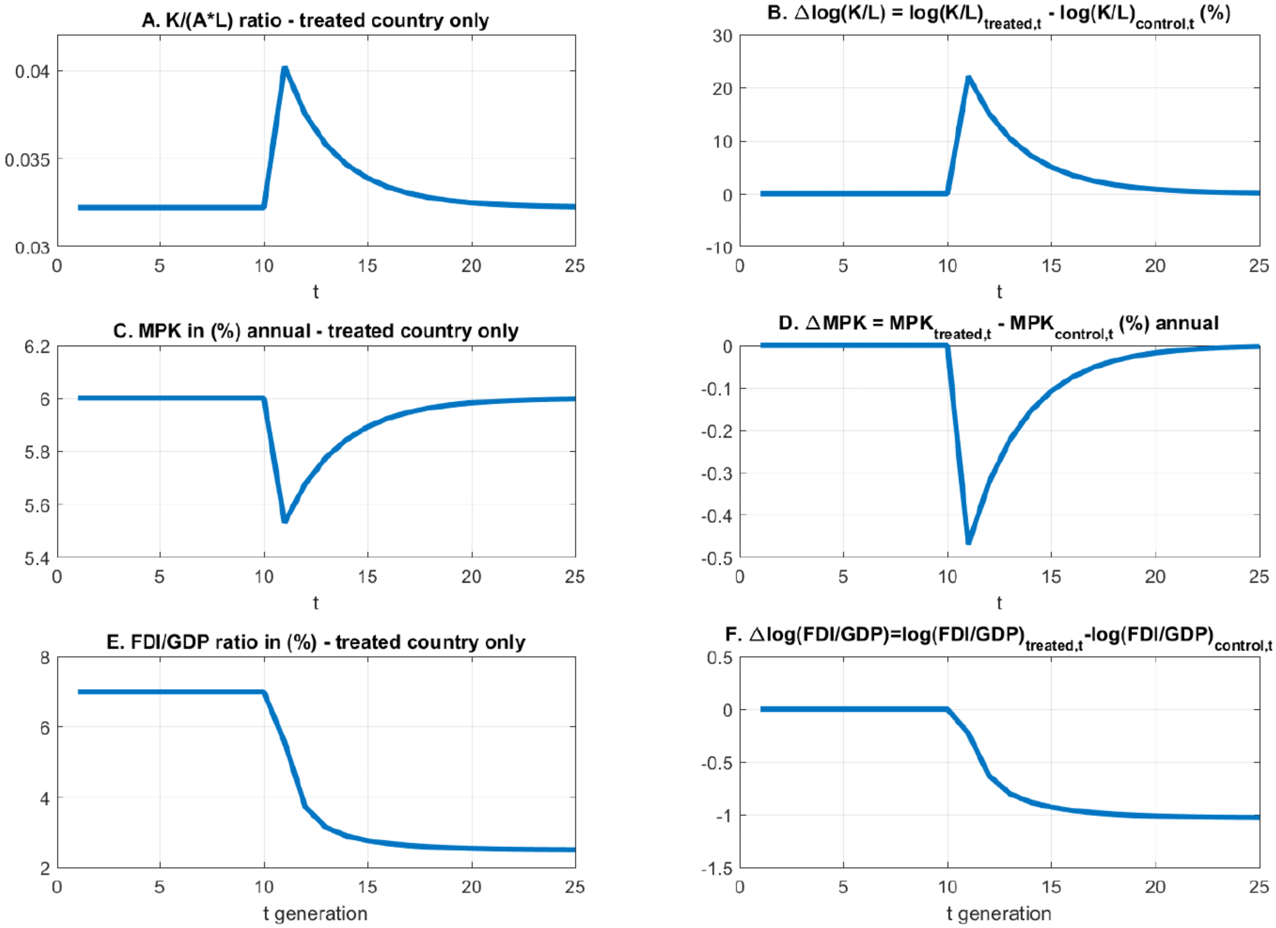

Figure 7 – Comparative time paths of K/L, MPK and FDI/GDP, for the two economies around the time of the demographic intervention (treatment for one country only).

Panels E and F detail the consequences of the intervention for the FDI/GDP ratio of the treated country. As evident in equation (25), the steady state FDI/GDP ratio of country i is positively related to its population growth rate $g_{L,i}$. Accordingly, a reduction in the treated country's $g_{L,i}$ reduces its FDI/GDP ratio, an effect manifested in Panel E. Relative to the control country, its FDI/GDP ratio declines as well (Panel F): although the K/L ratio of the treated country eventually returns to its pre-intervention values (Panel A), the composition of its ownership of its capital stock has changed in favor of proportionately less FDI. We summarize these model implications as follows: a permanent decline in the population growth rate of the treated country leads to, (i) a temporary, though prolonged, increase in the K/L ratio above its steady state value, (ii) a temporary, though prolonged, decrease in the marginal product of capital below its steady state value, and (iii) a permanent reduction in its FDI/GDP ratio both absolutely and relative to its control counterpart. Note that Panel A of Figure 7 depicts the time path of the *normalized* (by labor productivity, A) K/L ratio. The K/L ratio of both countries, except on the transition path for the treated country, thus continues to grow at the same growth rate as A.

The permanent decline in the relative FDI/GDP ratio following a permanent reduction in the treated country's population growth rate (Figure 7, Panel F) is not due to the temporarily lower marginal product of capital (Figure 7, Panel D) and thus lower capital returns. We emphasize that it is not the (temporarily) lower capital returns that discourage FDI. Rather, less FDI is needed since greater capital per worker is being inherited from the prior generation due to the reduction in the population growth rate in an environment where the savings rate is unchanged.[27] It is a "crowding-out" type effect. Model dynamics are thus in accord with data (Figure 5).

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[27] These results are robust to a reduced savings rate response to fewer descendants in a model of implicit voluntary bequests, provided the savings rate decline is not too great.

We present further evidence (Figure 8) in support of the 'crowding out' mechanism resulting from China's one child policy on FDI by exploring FDI as a share of domestic investment (FDI/I ratio) in China and India for the period 1982-2014.

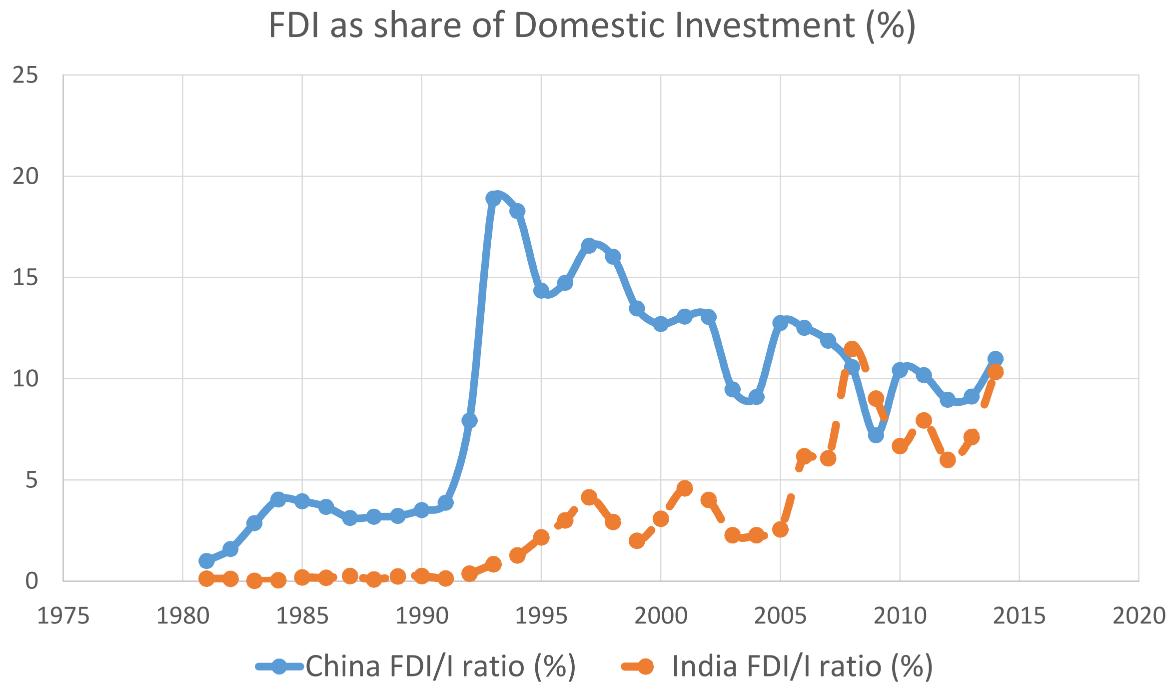

Figure 8 - FDI/I ratio in China and India

Prior to 1992, the FDI/I ratio was low in China and negligible in India. This is evident from Figure 8. While India's FDI/I ratio is generally increasing in the years following 1992, the pattern for China is one of an initial dramatic increase, followed by a pronounced general decline. A major reason for the initial increase in China's FDI/I ratio is easily identified. In 1992 the Chinese government formally established "market economy reforms" in its constitution and began to strengthen private property rights by enforcing the "rule of law" for commercial transactions. As a landmark on China's transition to a market economy, these reforms made China a dramatically more attractive place for foreign investment.[28] While

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[28] The second landmark year, 2001, marked China's accession to the World Trade Organization (WTO).

the observed decline in China's FDI/I ratio is theoretically consistent with the perspective of this paper – the "crowding out" of FDI by increases in China's K/L due to demographic repression – it may also be due to the dramatic increases in China's domestic household savings rate in this period (see Choukhmane et al. (2017)), a feature absent in the present model formulation. As noted earlier, however, introducing an increasing savings rate would only strengthen the model's prediction of a declining FDI/I ratio.

In summary, our theoretical predictions are as follows:

1. After a permanent drop in a country's population growth rate its FDI/GDP ratio will steadily decline to a new, permanently lower, level (see Figure 7, Panel E, and equation (25)).
2. After a permanent drop in a country's population growth rate, its FDI/I ratio will similarly decline to a new, permanently lower, level.

In Figure 8, China's FDI/I ratio does decline with time, in accordance with the theoretical predictions. In Figure 3, however, China's FDI/GDP ratio is seen to stabilize at around 4%, a seeming contradiction to the theory presented here.

We attribute this discrepancy to other factors at play, and, in particular, labor productivity growth. Specifically, Table 1 portrays a dramatic increase in China's productivity growth in the decades following 1982. Moreover, equation (25) implies a positive steady-state relationship between the FDI/GDP ratio and labor productivity growth. Taken together, these facts suggest that China's enhanced productivity growth post 1982, per se, would lead to a higher FDI/GDP ratio, and that this effect may overwhelm the opposing force of lower population growth emphasized in the present paper. Accordingly, we hypothesize that the FDI/GDP pattern evident in Figure 3 is the result of the effects of higher productivity growth and lower population growth counterbalancing one another.

Nevertheless, the fact that productivity growth was similar in China and India after 1982 allows us also to focus on *comparative FDI/GDP dynamics between China and India.* On Figure 4 we have focused on these comparative FDI/GDP dynamics, empirical observations that are replicated theoretically in Figure 7 (Panel F).

5. Relationship to the existing literature

The neoclassical foundation for dynamic FDI analysis was first articulated in McGrattan and Prescott (2009, 2010), and Holmes, McGrattan and Prescott (2015). These three studies introduce international capital flows in a fashion similar to the present model. The paradigms they consider assume that both population growth rates and labor-productivity growth rates are equal across countries (see McGrattan and Prescott, 2010, p. 1503, and Holmes, McGrattan and Prescott, 2015, p. 1172), an assumption necessary for the existence of steady states in their formulations.[29] In these papers both developed and developing countries have the same population growth, suggesting that developing countries catch up with the world production frontier mainly through capital deepening. Alternatively, the concept of "technology transfer" in McGrattan and Prescott (2009, 2010), and Holmes, McGrattan and Prescott (2015) represents another appropriate technique for analyzing, e.g., the post-World-War II transition of southern European economies toward the EU frontier.

From a pure demographic perspective, Backus et al. (2014) and Cooley and Henriksen (2018) are two additional works. In the former, the authors directly explore the implications

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[29] To see why this paradigm does not allow for steady states with heterogeneous rates of population growth across countries, consider an intertemporal Euler equation relating the growth rate of consumption to a constant world interest rate, r^*. With constant relative risk aversion γ, this Euler equation is given by $c^i_{t+1}/c^i_t = \left[\beta\left(1+r^*\right)\right]^{1/\gamma}$, with c^i_t being consumption in country i. With $\hat{c}^i_t$ denoting consumption in efficiency units for a model with constant exogenous population growth rate, $g_{L,i}$, and constant exogenous labor productivity growth, $g_{A,i}$, $\hat{c}^i_{t+1}/\hat{c}^i_t = e^{-g_{L,i}-g_{A,i}}\left[\beta\left(1+r^*\right)\right]^{1/\gamma}$. A steady state in which $\hat{c}^i_{t+1} = \hat{c}^i_t$ in efficiency units is impossible for all countries if population growth rates are heterogeneous. Other steady states are impossible, as well.

of differing population dynamics (life expectancies, population age distributions) for capital flows between countries. In the latter work the focus is more on the implications of population dynamics for economic growth rates within countries, particularly Japan and the US. The mechanism we have emphasized, however, is not showcased in these papers.

The present paper is also a contribution to the growing literature studying savings and investment in China. Bai et al. (2006) were the first to document the high capital returns in China (exceeding 20% post 1993) carefully. They conclude that China's high investment rate is consistent with the observed high returns. Song et al. (2011) explore the seeming contradiction implicit in China's simultaneous high capital returns and high capital outflows. Their model rests on the internal reallocation of capital out of low growth firms that are large, externally financed, and whose capital needs are low. In contrast, high growth, high productivity firms are small and subject to capital constraints. They thus finance their rapidly increasing investments out of internally generated funds alone. As a result, the surplus capital from low growth firms migrates abroad, while the relative growth in the high productivity firms allows high overall capital returns to be observed.[30] Nothing in the present model depends on the precise level of capital returns. The large literature that studies the impact of China's one-child policy on its national savings rate was noted in the introduction.

Finally, the ability of the model to replicate the facts depicted in Figure 3 does not contradict the Lucas paradox per se: FDI/GDP and K/L were higher in China compared to India throughout the entire sample period.[31] It does suggest, however, that the search

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[30] A more recent study also reporting high capital returns in China and focusing on the link between these returns and the housing boom in China, is Chen and Wen (2017).

[31] The present model is also able to replicate the Lucas (1990) paradox as a potential competitive equilibrium outcome. To see this, first note that by equation (24), the level of labor productivity, A_i, influences the K/L ratio. By equation (25), however, the level of labor productivity has no influence on the steady state FDI/GDP ratio. Imagine two countries, one with a lower β_i, a higher level of capital intensity α_i, and higher labor force and labor productivity growth rate. By equation (25) this country will have the higher steady-state FDI/GDP ratio (r^* and δ being common to both countries). If this country simultaneously enjoys labor productivity A_i dramatically above its counterpart, this high FDI/GDP ratio country will also

for neoclassical fundamentals underlying FDI flows may be more productively undertaken by exploring cross-country *relative* rather than absolute FDI dynamics.[32]

6. Conclusion

This paper is a contribution to the nascent literature on the role of FDI and technology transfer in international markets in the context of integrated capital markets (see McGrattan and Prescott, (2009, 2010), and Holmes, McGrattan and Prescott, (2015)). We emphasize the effects of cross-country heterogeneity in population growth on relative FDI flows, a topic not previously addressed in that literature. More specifically, the mandatory one-child policy in China is contrasted with India's comparatively laissez faire approach as a natural experiment to test for the presence of neoclassical FDI dynamics. Our evidence and analysis support the hypothesis that neoclassical fundamentals do govern *relative* FDI flows.

As in the literature cited above, we employ a straightforward OLG construct for our analysis, and focus on studying temporary, though prolonged departures from steady states. For emerging markets, real-world transitional dynamics which are far from the steady state, can be quite complicated, suggesting that the assumption of household perfect foresight may be too strong. The "myopia" (beyond an adult's life span of, e.g., 50-60 years) of an OLG model however, is perhaps the more appropriate starting point for capturing the rules of thumb used by savers in emerging economies.

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have a higher (K/L). Accordingly, more capital flows from the ROW to the richer of the two countries, where we measure wealth in terms of capital per worker. This is one version of the Lucas (1990) paradox in our neoclassical setting.

In fact, the high FDI/GDP, high A country described above resembles the USA in many respects: a country with a high absolute TFP level, high TFP growth by developed world standards, a high income share to capital and low savings (low β).

[32] Notably, this natural experiment could not showcase these mechanics back in 1990, when the Lucas-paradox paper was written.

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7. Online Appendix A – Proof of production aggregation

We omit time subscripts for simplicity. From equations (1), (2), (3), and (14), we obtain,

$$Y_i = A_i^{1-\alpha_i} \left(K_i^i\right)^{\alpha_i} \left(L_i^i\right)^{1-\alpha_i} \left[1 + \left(\frac{FDI_i^r}{K_i^i}\right)^{\alpha_i} \left(\frac{L_i^r}{L_i^i}\right)^{1-\alpha_i}\right] . \tag{27}$$

Assuming frictionless cross-country capital flows, condition (7) implies the equilibrium condition:

$$r^* + \delta = MPK_{1,t}^1 = MPK_{1,t}^r = MPK_{2,t}^2 = MPK_{2,t}^r . \tag{28}$$

Combining equations (28), (2), and (3), we obtain,

$$FDI_i^r \cdot L_i^i = K_i^i \cdot L_i^r . \tag{29}$$

Equation (27), combined with (29) and (4) becomes,

$$Y_i = A_i^{1-\alpha_i} \left(K_i^i\right)^{\alpha_i} \left(L_i^i\right)^{-\alpha_i} L_i . \tag{30}$$

Adding the term $K_i^i \cdot L_i^i$ to both sides of equation (29) leads to $(K_i^i + FDI_i^r) \cdot L_i^i = K_i^i \cdot (L_i^i + L_i^r)$, which implies,

$$\frac{K_i}{L_i} = \frac{K_i^i}{L_i^i} , \tag{31}$$

given (4), and given that $K_i = K_i^i + FDI_i^r$. Combining (30) with (31) we obtain

$$Y_i = A_i^{1-\alpha_i} \left(\frac{K_i}{L_i}\right)^{\alpha_i} L_i ,$$

which coincides with equation (15), proving the aggregation result. □

8. Online Appendix B - Proof of equations (23), (24), and (25)

Equation (22) implies $r^* + \delta = \alpha_i K_{i,t}^{\alpha_i - 1} \left(A_{i,t} L_{i,t}\right)^{1-\alpha_i}$, which gives,

$$K_{i,t} = \left(\frac{\alpha_i}{r^* + \delta}\right)^{\frac{1}{1-\alpha_i}} A_{i,t} L_{i,t} \ . \tag{32}$$

Substituting (32) into (15) gives equation (23).

To prove (24), notice that (13) and (15) give,

$$K_{i,t+1}^i = (1-\delta) K_{i,t}^i + \frac{\beta_i (1-\alpha_i)}{1+\beta_i} Y_{i,t} \ . \tag{33}$$

Substituting (33) into (23) implies,

$$K_{i,t+1}^i = (1-\delta) K_{i,t}^i + \frac{\beta_i (1-\alpha_i)}{1+\beta_i} \left(\frac{\alpha_i}{r^* + \delta}\right)^{\frac{\alpha_i}{1-\alpha_i}} A_{i,t} L_{i,t} \ . \tag{34}$$

Dividing both sides of equation (34) by $A_{i,t} L_{i,t}$, and considering constant exogenous growth rates for technology and population, $g_{A,i}$ and $g_{L,i}$, we obtain,

$$e^{g_{A,i} + g_{L,i}} \frac{K_{i,t+1}^i}{A_{i,t+1} L_{i,t+1}} = (1-\delta) \frac{K_{i,t}^i}{A_{i,t} L_{i,t}} + \frac{\beta_i (1-\alpha_i)}{1+\beta_i} \left(\frac{\alpha_i}{r^* + \delta}\right)^{\frac{\alpha_i}{1-\alpha_i}} \ . \tag{35}$$

After placing domestic capital in efficiency units, $K_{i,t}^i / \left(A_{i,t} L_{i,t}\right)$, on a zero-growth steady-state path, so that $\left(K_{i,t}^i\right)^{ss} / \left(A_{i,t} L_{i,t}\right) = \left(K_{i,t+1}^i\right)^{ss} / \left(A_{i,t+1} L_{i,t+1}\right)$, equation (35) implies,

$$\left(K_{i,t}^i\right)^{ss} = \frac{\beta_i (1-\alpha_i)}{(1+\beta_i)\left(e^{g_{A,i} + g_{L,i}} + \delta - 1\right)} \underbrace{\left(\frac{\alpha_i}{r^* + \delta}\right)^{\frac{\alpha_i}{1-\alpha_i}} A_{i,t} L_{i,t}}_{\overset{\shortparallel}{Y_{i,t}^{ss}}} \ , \tag{36}$$

proving equation (24).

For proving equation (25), observe that equation (22) implies,

$$\frac{K_{i,t}^{ss}}{Y_{i,t}^{ss}} = \frac{\alpha_i}{r^* + \delta} \ . \tag{37}$$

Equation (6) together with (37) gives,

$$\frac{\left(K_{i,t}^{i}\right)^{ss}}{Y_{i,t}^{ss}}+\frac{\left(FDI_{i,t}^{r}\right)^{ss}}{Y_{i,t}^{ss}}=\frac{\alpha_i}{r^*+\delta}\ . \tag{38}$$

Equation (36) combined with (23) implies,

$$\frac{\left(K_{i,t}^{i}\right)^{ss}}{Y_{i,t}^{ss}}=\frac{\beta_i\left(1-\alpha_i\right)}{\left(1+\beta_i\right)\left(e^{g_{A,i}+g_{L,i}}+\delta-1\right)}\ . \tag{39}$$

Combining (38) and (39) proves equation (25). □

Appendix C - Data Descriptions and Sources

year	China FDI/GDPratio (%)	India FDI/GDPratio (%)	Ratio	log(ratio)
1981	0.155	0.027	5.822	0.765
1982	0.239	0.022	10.731	1.031
1983	0.430	0.002	255.079	2.407
1984	0.661	0.006	111.110	2.046
1985	0.824	0.032	25.571	1.408
1986	0.710	0.028	25.256	1.402
1987	0.613	0.043	14.218	1.153
1988	0.707	0.016	44.807	1.651
1989	0.751	0.043	17.615	1.246
1990	0.709	0.048	14.783	1.170
1991	0.800	0.022	35.780	1.554
1992	1.750	0.070	24.988	1.398
1993	3.930	0.146	26.934	1.430
1994	4.198	0.246	17.046	1.232
1995	3.832	0.476	8.044	0.905
1996	4.074	0.544	7.489	0.874
1997	4.402	0.801	5.495	0.740
1998	4.251	0.555	7.655	0.884
1999	3.450	0.431	7.997	0.903
2000	3.321	0.637	5.216	0.717
2001	3.744	0.974	3.845	0.585
2002	3.781	0.934	4.048	0.607
2003	3.033	0.561	5.407	0.733
2004	3.092	0.660	4.687	0.671
2005	4.240	0.783	5.418	0.734
2006	4.290	1.978	2.168	0.336
2007	4.404	2.070	2.127	0.328
2008	4.322	3.518	1.228	0.089
2009	3.234	2.952	1.095	0.040
2010	4.914	2.209	2.224	0.347
2011	4.811	2.597	1.853	0.268
2012	4.178	1.816	2.300	0.362
2013	4.290	1.989	2.157	0.334
2014	5.132	2.829	1.814	0.259

Table A.1 Data on FDI/GDP ratios

Foreign Direct Investment[1]

We use four different data sources to cross-verify the FDI inflows and outflows of China and India.

1. OECD: 1990-2013. Historic time series from OECD FDI statistics to end-2013 (http://www.oecd.org/daf/inv/investment-policy/fdi-statistics-according-tobmd3.htm).
2. National Accounts: 1982 – 2014. National Bureau of Statistics China (NBS-China) provides FDI outflow and inflow information (http://data.stats.gov.cn/english/index.htm).
3. UNCTAD (United Nations Conference on Trade and Development): 1981-2013.The UNCTAD work program on FDI Statistics documents and analyzes global and regional trends in FDI.
4. DataStream: 1981-2016 (Quarterly). Thomson Reuters DataStream provides quarterly data on FDI inflows and outflows for China and India.[2]

Population Estimates and Forecasts: 1950-2100. United Nations: probabilistic population projections based on the world population prospects (the 2015 revision)[3].

GDP Series: 1990-2014, 2015-2018 (estimates). Work Bank, PPP adjusted at constant 2011 international USD.

Capital Stock -GDP ratio (K/Y ratio): PWT 9.0 (The Penn World Table).

FDI data come from four sources: (a) National Accounts, (b) OECD, (c) Datastream, and (d) UNCTAD. These sources cover different years, so we specify which we use in each context and document the correlation among these data sources. National account data for India is downloaded from the RBI website (https://rbi.org.in/Scripts/SDDSView.aspx) and it is identical to the data provided by OECD. So, we only report the OECD source.

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[1] All FDI statistics from different sources use 2010 USD as the base dollar value.

[2] The quarterly data sources are composed by Oxford Economics (http://www.oxfordeconomics.com/).

[3] United Nations (2015). Probabilistic Population Projections based on the World Population Prospects: The 2015 Revision. Population Division, DESA. http://esa.un.org/unpd/ppp/.

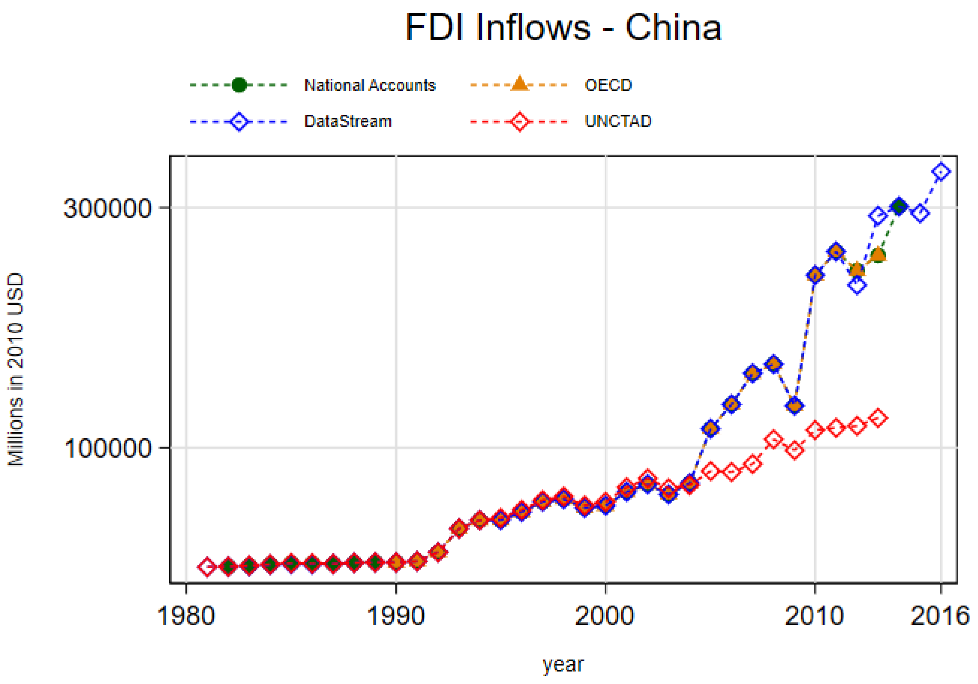

Figure A.1

The sources used in the paper are National-accounts data for the period 1982-2014 and Datastream data for years 2015-2016. National-accounts data and Datastream data overlap over the period 1982-2014 with a correlation coefficient of 99.79%.

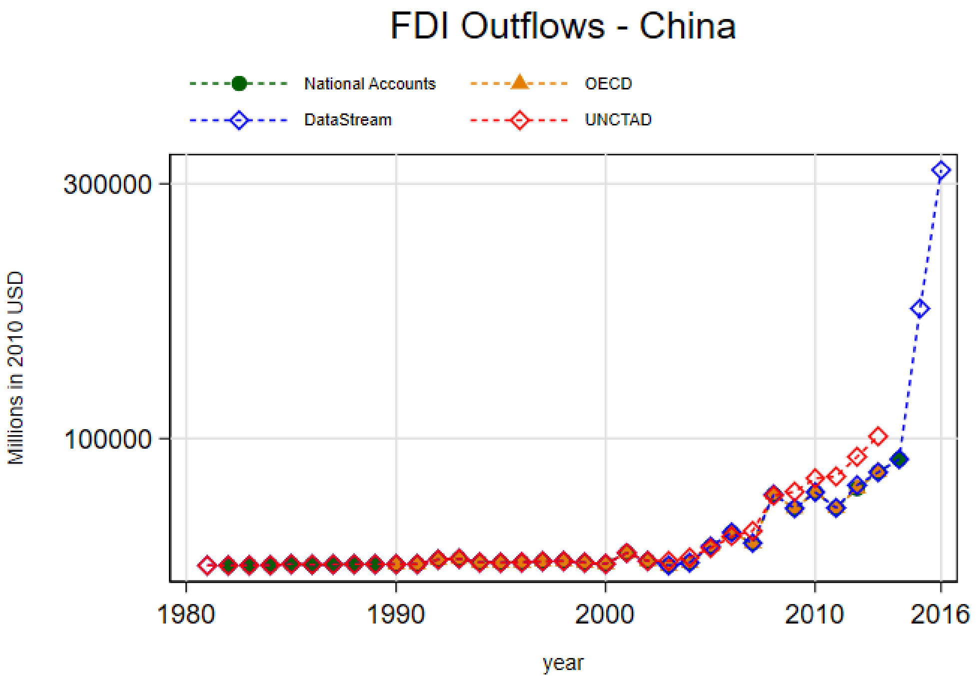

Figure A.2

The sources used in the paper are National-accounts data for the period 1982-2014 and Datastream data for years 2015-2016. National-accounts data and Datastream data overlap over the period 1982-2014 with a correlation coefficient 99.99%.

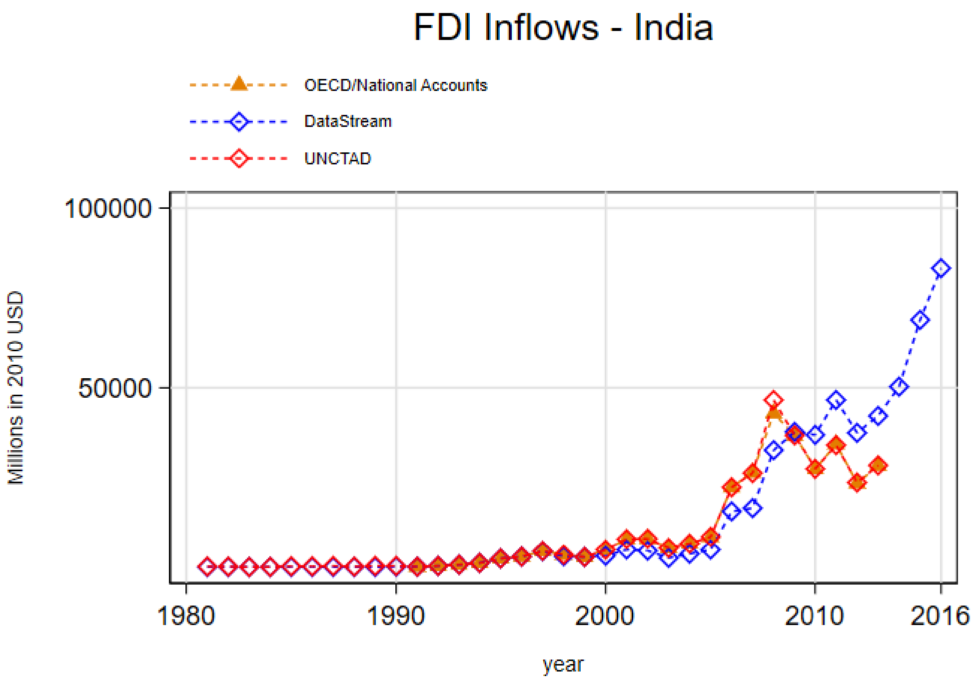

Figure A.3

The sources used in the paper are UNCTAD data for the period 1981-2013 and Datastream data for years 2014-2016. UNCTAD data and Datastream data overlap over the period 1981-2013 with a correlation coefficient of 92.56%. The reason we have chosen UNCTAD data for the period 1981-2013 is because, (a) for the period between 1981 and 1989 Datastream reports zero values (but not missing values), and (b) the two data sources overlap over the period 1991-2013 with a correlation coefficient of 99.87%.

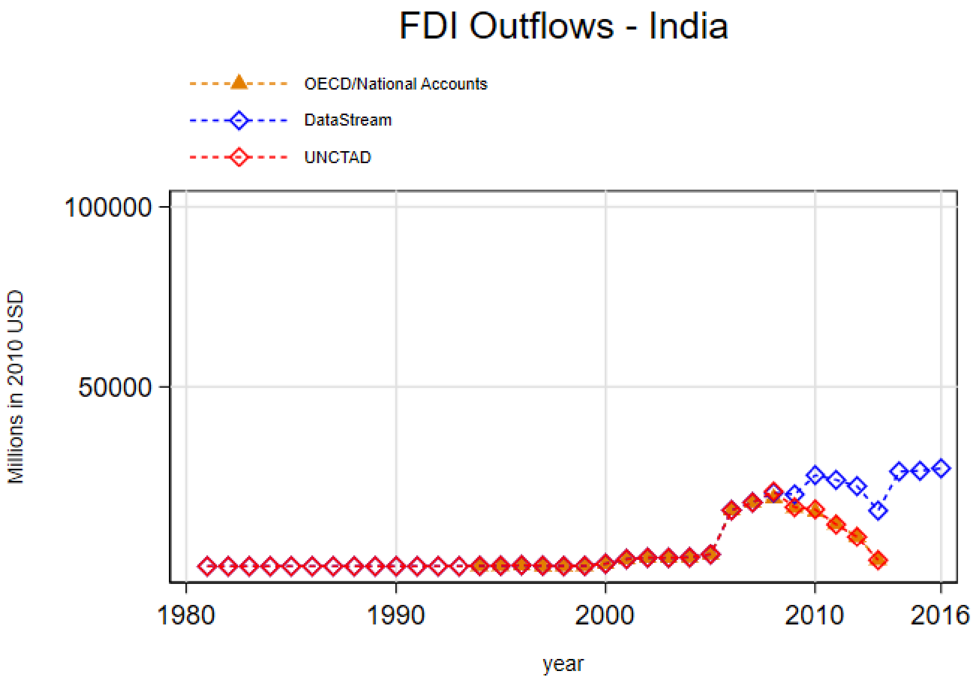

Figure A.4

The sources used in the paper are UNCTAD data for the period 1981-2013 and Datastream data for years 2014-2016. UNCTAD data and Datastream data overlap over the period 1981-2013 with a correlation coefficient of 89.32%. The reason we have chosen UNCTAD data for the period 1981-2013 is because, (a) for the period between 1981 and 1993 Datastream reports zero values (but not missing values), and (b) the two data sources overlap over the period 1994-2013 with a correlation coefficient of 99.86%.

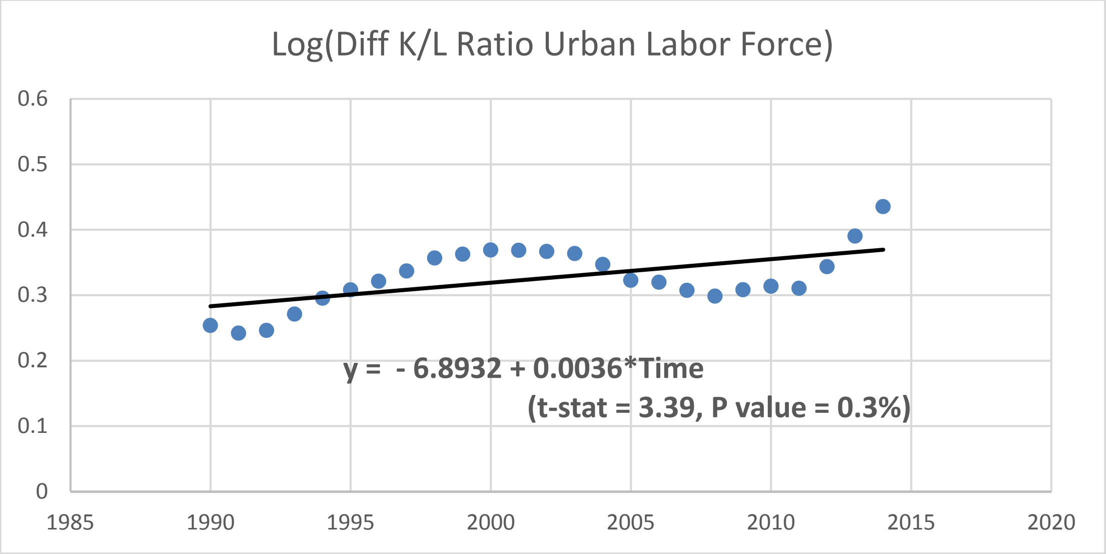

Figure A.5

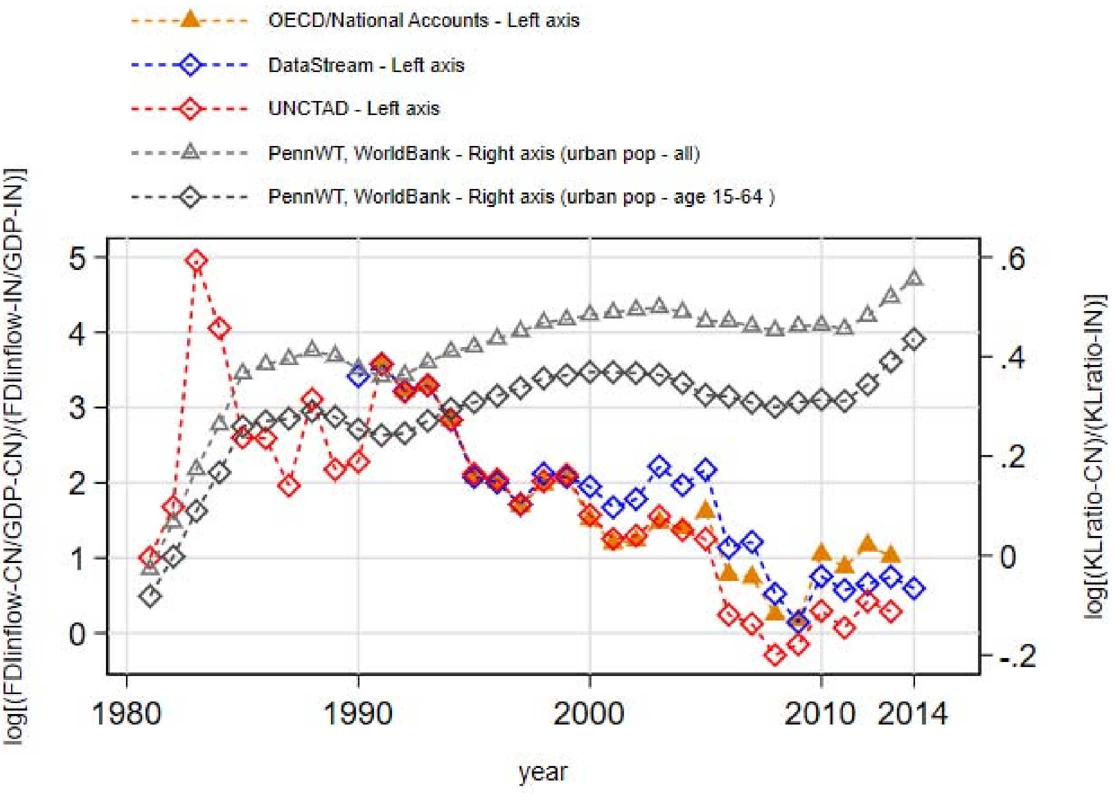

Figure A.6

To address the concern that large-scale internal migration in China would decrease the capital-labor ratio instead of increasing it, we use the urban population, restricted to ages 15-64 and perform a robustness check. Figure A.5 shows that the linear time trend coefficient (of the log K/L ratio of China over the K/L ratio of India) is positive and statistically significant (not equal to 0 with p-value at 0.3%). In Figure A.6 where we plot a similar data series as Figure 5 (in the paper) using this restricted sample, all the quantitative results remain.

The first two columns of Table A.2 provide the data appearing in Figure A.6 (without the logarithmic conversion of ratios). The last two columns of Table A.2 are the two new urban (working) population series appearing in Figure A.6.

year	Ratio_FDIY	Ratio_FullPop	Ratio_PopUrban	Ratio_PopUrbanWorking
1990	30.45	0.96	1.46	1.29
1991	35.73	0.99	1.43	1.27
1992	25.08	1.02	1.44	1.28
1993	26.94	1.07	1.47	1.31
1994	17.04	1.13	1.51	1.34
1995	7.96	1.17	1.52	1.36
1996	7.42	1.22	1.55	1.38
1997	5.54	1.27	1.57	1.40
1998	8.32	1.32	1.60	1.43
1999	7.95	1.36	1.61	1.44
2000	7.02	1.41	1.62	1.45
2001	5.33	1.50	1.63	1.45
2002	5.94	1.57	1.64	1.44
2003	9.19	1.66	1.65	1.44
2004	7.14	1.73	1.63	1.41
2005	8.79	1.72	1.60	1.38
2006	3.11	1.72	1.60	1.38
2007	3.36	1.71	1.59	1.36
2008	1.69	1.68	1.57	1.35
2009	1.16	1.70	1.59	1.36
2010	2.12	1.72	1.59	1.37
2011	1.77	1.72	1.58	1.36
2012	1.92	1.77	1.62	1.41
2013	2.11	1.87	1.68	1.48
2014	1.81	1.97	1.74	1.55

Table A.2

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