Fertility and Internal Migration

Pei-Ju Liao, Ping Wang, Yin-Chi Wang, and Chong K. Yip

While there is a renewed literature connecting internal migration to various issues related to structural transformation such as urban labor and housing markets, the relationship between internal migration and demographic transition is much under-studied despite its importance in the process of economic development. Our article fills this knowledge gap. By constructing a simple dynamic framework in which fertility and rural-urban migration decisions are both determined, we show that more-rapid urban productivity advancement can lead to a positive relationship between migration and fertility. Using cross-country data analysis, we support our theory, establishing that both migration and fertility rates are higher in less-developed countries than in advanced economies. Our results imply that policies that may help reduce the cost of urban living or enhance urban benefits would be useful for productive structural transformation. (JEL E24, O15,R23)

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1 INTRODUCTION

Since the novel contributions by Todaro (1969) and Harris and Todaro (1970), there have been numerous studies on urbanization and structural transformation in developing economies. Not until 20 or so years ago, however, did economists embed internal migration into a dynamic general equilibrium framework. The new strand of the literature has connected internal migration to various issues related to structural transformation, including urban labor and housing markets as well as geographic job and income distribution.

By matching three internationally comparable datasets, we establish some useful stylized facts, particularly on migration and fertility measures across countries at different stages of economic development. Our cross-country data analysis suggests a positive correlation between migration and fertility. Moreover, countries exhibiting higher migration and fertility rates are found to be less developed. Thus, rural-urban migration led by urban total factor

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productivity (TFP) growth may be viewed as a key driver that may transform a less-developed economy from "Malthus to Solow," using the terminology in Hansen and Prescott (2002).

Accordingly, we provide a simple dynamic framework in which both fertility and rural-urban migration decisions are endogenously determined.[1] More-rapid advancement in urban TFP relative to rural TFP induces structural transformation from farming to manufacturing. At the balanced-growth spatial equilibrium, there are opposing forces at work for the comparative static outcomes of migration and fertility. We establish conditions under which migration intensity (defined as migration flow divided by the rural population) and the total fertility rate turn out to be positively related, in response to more-rapid urban TFP advancement. The economics are intuitive: When urban TFP continues to rise over time, a higher urban wage encourages migration from rural to urban areas and leads to a fall in the rural-to-urban (rural-urban) population ratio. The decline in this ratio has two opposite effects on migration intensity. First, it causes a direct drop in migration intensity, which we call the population base effect. Second, because the urban fertility rate is lower than the rural fertility rate, the decline in the rural-urban population ratio also leads to a decline in the total fertility rate.[2] Given the same migration flow, the decline in the rural-urban population ratio increases migration intensity, which we call the population growth effect. As long as the direct population base effect on migration intensity dominates the indirect population growth effect, an ongoing rise in relative urban TFP can deliver a positive relation between migration intensity and the total fertility rate. In this case, an economy with a higher relative income is associated with a combination of low migration intensity and low fertility.

The policy implication of our findings is important for economic development. We find that rural-urban migration not only shifts labor from agriculture to more-productive non-agriculture sectors, but is also associated with a decline in fertility accompanied by higher per capita income as a result of labor reallocation across locations. Our results imply that policies that may help reduce the cost of urban living or enhance urban benefits would be useful for productive structural transformation.

Finally, we conclude the article by pointing out the knowledge gap, especially what existing theory may still fail to address and what may be potentially rewarding for future studies.

2 LITERATURE REVIEW

In this section, we provide a critical review of the new strand of the literature connecting internal migration to various issues related to structural transformation.

Bencivenga and Smith (1997) and Banerjee and Newman (1998) represent the first generation of this strand of research with thorough modeling of internal migration dynamics in the presence of informational asymmetry. While Bencivenga and Smith (1997) find adverse selection of workers into urban areas as a result of asymmetric information, Banerjee and Newman (1998) show lower credit availability in the process of internal migration, due to higher agency costs. Both articles are interesting, but asymmetric information is not viewed as the primary driver of the great divergence in the speed of urbanization.

Lucas (2004) pioneers the second generation of this strand of research and focuses on explaining the great divergence. More specifically, cities enable new migrants to accumulate human capital for better earnings, but rural areas remain active due to the presence of a specific factor: land. When more rural workers migrate to urban areas, the remaining rural farmers own more cultivatable land and thus enjoy a rising marginal product and higher returns. Eventually, rural-urban migration ceases when the values of earnings in rural and urban areas equalize. The speed of urbanization thereby depends on the return to human capital accumulation in urban areas relative to land productivity in rural areas. Using a search and matching framework, Laing, Park, and Wang (2005) stress that reductions in labor market frictions may reduce the likelihood of unemployment, induce higher wage offers, and lead to a faster process of urbanization. More recently, Bond, Riezman, and Wang (2016) argue that trade liberalization together with reductions in migration barriers are key drivers of rural-urban migration. While the effect of migration barriers is clear, reduced trade costs induce firms in developing countries to produce more capital-intensive, import-competing goods rather than low-skilled-labor-intensive exportables. The resulting increase in urban productivity thus induces faster urbanization and leads to faster growth.

The third generation of this strand of research not only broadens the spectrum of issues examined but also conducts more comprehensive quantitative studies than the second generation. Following Lucas (2004) in stressing the importance of human capital, Liao et al. (2017) highlight urban education as an incentive for migration, finding that education-based migration could be more crucial than work-based migration in the case of China, where attending colleges mitigates large mobility barriers. Liao et al. (2020) further point out that, despite the lower childrearing cost in rural compared with urban areas, cities provide better opportunities for both economic and non-economic activities. Liao et al. thus develop an internal migration model featuring a locational quantity-quality trade-off of children and find that stricter population control policies in Chinese cities may not be ideal. Particularly, such policies may reduce migration incentives of workers with stronger preferences toward having children, subsequently leading to distorted outcomes in migration and fertility. Focusing on urban housing booms in China, Garriga et al. (2017) find that housing price hikes are largely fundamental, driven by urban TFP-induced rural-urban migration and amplified by continual reductions in migration barriers. Ngai, Pissarides, and Wang (2019) claim that the household registration system prevented labor from moving out of the agricultural sector and subsequently slowed down the process of structural transformation and industrialization in China. The rationale is that the household registration system did not fully secure tenure rights to land, resulting in an inefficient land rental market, underestimation of the effective urban income, and overemployment in the low-productivity agricultural sector. Moreover, the provision of social transfers that were conditional on the area of registration discouraged "floating workers" and subsequently yielded underemployment in the urban non-agricultural sector. Finally, by generalizing the Bond-Riezman-Wang framework to multiple regions, Tombe and Zhu (2019) find that, in the absence of capital, internal reforms on trade and migration are more important for enhancing growth in China than international trade.

While an important factor interacting with internal migration is demographic transition, it is unfortunately under-studied. There are a few exceptions. In Sato and Yamamoto (2005), the decline in infant and child mortality, as typically observed in demographic transition, is a main driver for urbanization. Sato (2007) further argues that when the substitution effect and the income effect on fertility offset each other, the interaction of urban agglomeration economies (Lucas 1988) and urban congestion with the fertility-work trade-off can generate a negative relationship between income and fertility across different regions. More recently, Cheung (2018) proposes rural education reform as a critical force leading to demographic transition accompanied by a shift from rural farming to urban manufacturing. Liao et al. (2020) examine how work-based rural-urban migration and fertility decisions interplay in the process of economic development when the economy exhibits large migration frictions and population controls. Our article complements Sato and Yamamoto (2005) and Sato (2007): While their articles focus on internal migration and local fertility patterns across different regions in a country, our article characterizes rural-urban migration and overall fertility of a country over time.

3 DATA ANALYSIS

In this section, we use real gross domestic product (GDP) per capita from Penn World Table (PWT) 9.0, the total fertility rate from the World Development Indicators (WDI), and migration intensity from Bernard, Bell, and Cooper (2018, Table A4.1) to study the cross-country patterns of internal migration and fertility. To be in line with previous studies cited in this article, our data analysis focuses exclusively on the levels of migration intensity and fertility.

The migration intensity data reported in Bernard, Bell, and Cooper (2018) are based on census data from 1996 to 2011. Migration intensity refers to crude migration intensity of major areas.[3] In an earlier work, Bell et al. (2002) provide more detailed discussion on the definition of crude migration as well as the related adjustments needed for ensuring comparability of the cross-country data.

Accordingly, we focus on cross-country patterns for the period 1996 to 2015. The United States is set as the benchmark country, so relative income is calculated as real GDP per capita relative to that of the United States. We capture different development stages of sample countries based on their initial development stage measured by relative income in 1996 and their development achievement measured by relative income in 2015.

Table 1 provides the summary statistics of total migration intensity and the total fertility rate. Their relationship is illustrated by the scatter plot in Figure 1. Here, the total fertility rate refers to the "middle year" of our sample period, 2006. The main finding is that the total fertility rate is positively correlated with migration intensity, with a correlation coefficient of 0.2411. Moreover, based on the scatter plot, one can conclude that people in developing countries are more likely to have more children and are more likely to migrate than their counterparts in developed countries. This positive correlation between fertility and migration intensity lends empirical support to the model developed in this article.

Liao et al. (2019) find that migration intensity decreases moderately with initial relative income in 1996 (with a correlation coefficient of –0.0767) and that the total fertility rate falls sharply with it (with a correlation coefficient of –0.5965). They also show that when both nega-

Table 1

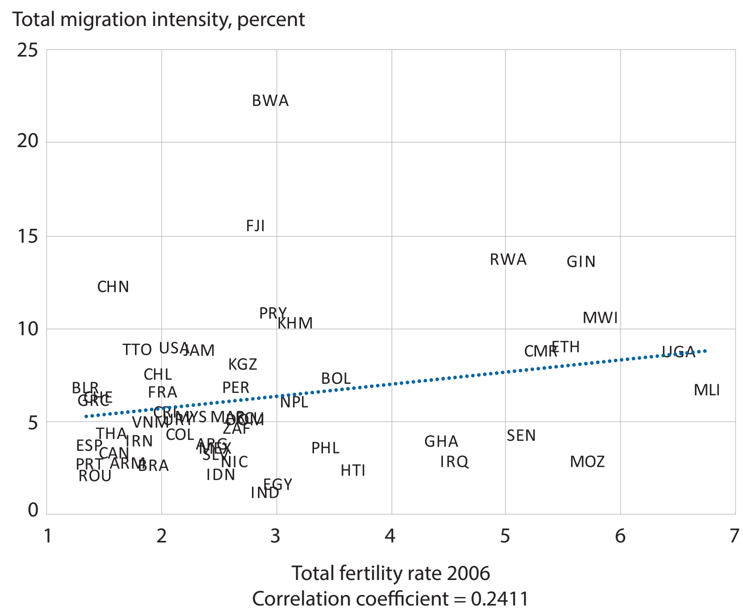
Summary Statistics

	Total migration intensity	Total fertility rate
Mean	6.328%	2.956
Standard deviation	3.947	1.436
Coefficient of variation	0.624	0.486

SOURCE: Authors' calculations using data from the WDI and Bernard, Bell, and Cooper (2018).

Figure 1

Migration Intensity and the Total Fertility Rate, 2006



NOTE: The dotted line is the linear regression line.
SOURCE: The WDI and Bernard, Bell, and Cooper (2018).

tive correlations are plotted against final relative income in 2015, the correlations are slightly weakened over the span of 20 years (with the correlation coefficients dropping to –0.0728 and –0.5475, respectively). Taking these results together, we may still infer a positive association between fertility and migration intensity. We turn now to constructing a model to rationalize this relationship.

4 THE MODEL

Time is discrete, indexed by t. Consider a two-location economy that extends the locational stratification model of Bénabou (1996) and the surplus labor model of Bond, Riezman, and Wang (2016). One location is called the urban area: It has most of the economic activity and is indexed by superscript U. The other is called the rural area: It plays a passive role and is indexed by superscript R. The economy is populated with two cohorts of two-period-lived overlapping generations, referred to as the young and the old. Each individual is endowed with one unit of productive time when young. To simplify the setup, we normalize our model to be populated only by females. The population is growing and depends on each individual's fertility choice at the beginning of the second period of life. Similar to Becker (1960), who was the first to introduce the quantity of children into parents' preferences, we assume that an individual is altruistic, valuing her own consumption when old (c) and number of children (n). Furthermore, because the quantity-quality tradeoff of children is not the focus of our underlying mechanism of rural-urban migration, we follow Sato (2007) to abstract from the quantity-quality choice of fertility decisions.[4] As such, the only cost considered here is a resource cost of childrearing at the rate of $\phi^j > 0$ per child, $j = R,U$.

The economic activity in the rural area is stripped down to the bare necessities. Basically, rural production is just backyard farming, yielding a crop income of w^R in units of the urban good, which is also rural workers' implicit self-employment wage. The lifetime utility of a rural farmer is given by

$$U^R = \ln c + \beta \ln n^R = \ln\left(w^R - \phi^R n^R\right) + \beta \ln n^R, \tag{1}$$

where $\beta \in (0,1)$ is the altruistic factor (common to all individuals). Thus, the optimization problem is

$$\max_{n^R} \ln\left(w^R - \phi^R n^R\right) + \beta \ln n^R,$$

which implies a first-order condition:

$$\underbrace{\frac{\beta}{n^R}}_{\text{MB}} = \underbrace{\frac{\phi^R}{w^R - \phi^R n^R}}_{\text{MC}}. \tag{2}$$

Because the marginal benefit (MB) from childbearing is decreasing in n and the marginal cost (MC) is increasing, the second-order condition is met, thus ensuring the solution maximizes lifetime utility. Manipulating this condition gives the solution for fertility:

$$n^R = \frac{\beta w^R}{(1+\beta)\phi^R}, \tag{3}$$

which is increasing in the altruistic factor and rural income but decreasing in the childrearing cost.

In the urban area, there is more economic activity. Individuals residing in the urban area are indexed by i and differ in their disutility from work δ_i—that is, a more-able urban worker suffers less from a utility loss, even though everyone earns the same market wage w^U. Notably, the setting captures the conventional labor-leisure trade-off in which working is costly as a result of reduced leisure time. An agent who resides in the urban area inelastically supplies one unit of labor, which induces a fixed utility loss. Those who would suffer too high a utility loss would thus always prefer to stay in the rural area. For simplicity, we assume that disutility for the urban area (δ_i) is always drawn from the same stationary distribution, which is fixed over time. The lifetime utility of an individual *i* living in urban is given by

$$U_i^U = \ln c_i + \beta \ln n_i^U - \delta_i, \tag{4}$$

whereas the budget constraint is

$$c_i + \phi^U n_i^U = w^U, \tag{5}$$

which can be substituted into lifetime utility to derive

$$\max_{n_i^U} \ln\left(w^U - \phi^U n_i^U\right) + \beta \ln n_i^U - \delta_i.$$

The solution is of similar form:

$$n_i^U = n^U = \frac{\beta w^U}{(1+\beta)\phi^U}. \tag{6}$$

Two remarks are in order. First, because disutility from work δ_i does not affect the net MB from childbearing, all individuals have the same fertility decision: $n_i^U = n^U$. Second, urban females bear fewer children than rural females do if the relative childrearing cost is higher in the urban area; that is, $\frac{\phi^U}{w^U} > \frac{\phi^R}{w^R}$, which is as observed in the real world, as daycare in urban areas is relatively more expansive. We conveniently define the childrearing cost gap as Φ, so $\frac{\phi^U}{w^U} \Big/ \frac{\phi^R}{w^R} = 1 + \Phi$.

Denote the population in location *j* at the end of time *t* as N_t^j. With a common solution of fertility within each location and without international immigration, we can write the economy-wide population evolution equations in a parsimonious manner:

$$\begin{aligned} N_{t+1} &= N_{t+1}^R + N_{t+1}^U = N_t^R\left(1+n^R\right) + N_t^U\left(1+n^U\right) \\ &= N_t^R\left[1 + \frac{\beta w^R}{(1+\beta)\phi^R}\right] + N_t^U\left[1 + \frac{\beta w^U}{(1+\beta)\phi^U}\right] \\ &= N_t\left[1 + \frac{\beta w^R}{(1+\beta)\phi^R}\right] + N_t^U \frac{\beta w^R}{(1+\beta)\phi^R}\left[\frac{\phi^R / w^R}{\phi^U / w^U} - 1\right], \end{aligned}$$

or

$$N_{t+1} = N_t\left[1 + \frac{\beta w^R}{(1+\beta)\phi^R}\right] - N_t^U \frac{\beta w^R}{(1+\beta)\phi^R} \frac{\Phi}{1+\Phi}. \tag{7}$$

Now, let us denote M_{t+1} as net flow migration from the rural to the urban area. Then, the population in each location evolves according to

$$N_{t+1}^R = N_t^R\left(1+n^R\right) - M_{t+1} \tag{8}$$

$$N_{t+1}^U = N_t^U\left(1+n^U\right) + M_{t+1}. \tag{9}$$

To ensure *spatial equilibrium*, we specify a *locational no-arbitrage condition* (LNAC) for the marginal migrant in each period. Under a stationary distribution of disutility types of new borns, the LNAC is given by

$$U_{i^*}^U = U^R, \tag{10}$$

where i^* indicates the marginal migrant who feels indifferent between staying in the rural area or migrating to the urban area. That is,

$$\ln\left(\frac{w^U}{1+\beta}\right) + \beta\ln\frac{\beta w^U}{(1+\beta)\phi^U} - \delta_{i^*} = \ln\left(\frac{w^R}{1+\beta}\right) + \beta\ln\frac{\beta w^R}{(1+\beta)\phi^R},$$

or

$$\delta_{i^*} = \ln\left(\frac{w^U}{w^R}\right) + \beta\ln\frac{w^U/\phi^U}{w^R/\phi^R} = \ln\left(\frac{w^U}{w^R}\right) - \beta\ln(1+\Phi). \tag{11}$$

Intuitively, the larger the urban-rural wage gap (w^U/w^R) or the smaller the urban-rural child-rearing cost gap (Φ), the higher the disutility cutoff (δ_{i^*}) and hence the higher the net migration flow from the rural to the urban area (M).

To close the model, we solve the labor market equilibrium in both locations. With a rural linear backyard-farming technology $Y^R = A^R N^R$, the implicit wage is tied to TFP: $w^R = A^R$. Let there be a continuum of identical and perfectly competitive firms of unit mass in the urban area. The production technology of an urban firm is assumed to take a Romer (1986) form:

$$Y^U = A^U\left(N^U\right)^{\alpha}\left(\overline{N^U}\right)^{1-\alpha}, \tag{12}$$

where $\alpha \in (0,1)$ and $\overline{N^U}$ is the aggregate employment in the urban area, taken as given by each firm but equal to N^U in equilibrium; that is, $N^U = \overline{N^U}$ ex post. This is a spatial agglomeration force driven by the Marshallian externality. This simple Romer form implies individual decreasing returns to scale ($\alpha < 1$) but social constant returns (the powers of N^U and $\overline{N^U}$ add up to 1).[5] Under this setup, the urban wage is simply

$$w^U = \alpha A^U.$$

5 CHARACTERIZATION OF THE SPATIAL EQUILIBRIUM

We are now ready to characterize the spatial equilibrium. Before establishing the key relationship between fertility and internal migration, we examine several useful urban-rural ratios.

To begin, the urban-rural wage ratio is

$$\frac{w^U}{w^R}=\alpha\frac{A^U}{A^R}, \tag{13}$$

depending positively on the urban-rural TFP gap and the urban returns-to-scale measure α. The childrearing cost gap and hence the rural-urban fertility differential become

$$\frac{n^R}{n^U}=1+\Phi=\frac{\phi^U}{w^U}\Big/\frac{\phi^R}{w^R}=\frac{\phi^U/\phi^R}{\alpha A^U/A^R}, \tag{14}$$

which is decreasing in the urban-rural TFP gap and urban returns to scale, but increasing in the relative childrearing cost in the urban area. Using (13), we can rewrite the LNAC (11) as

$$\begin{aligned}\delta_{i^*}&=\ln\alpha+\ln\left(\frac{A^U}{A^R}\right)-\beta\ln\left(\frac{\phi^U/\phi^R}{\alpha A^U/A^R}\right)\\&=(1+\beta)\ln\alpha+(1+\beta)\ln\left(A^U/A^R\right)-\beta\ln\left(\phi^U/\phi^R\right),\end{aligned} \tag{15}$$

which is increasing in the urban-rural TFP gap but decreasing in the relative childrearing cost in the urban area, which we conveniently refer to as the *spatial equilibrium condition* (SEC). The urban-rural output ratio is

$$\frac{Y^U}{Y^R}=\frac{A^U}{A^R}\frac{N^U}{N^R}, \tag{16}$$

whereas the urban-rural per capita income ratio is entirely driven by the TFP ratio:

$$\frac{y^U}{y^R}=\frac{Y^U/N^U}{Y^R/N^R}=\frac{A^U}{A^R}. \tag{17}$$

We next derive the total fertility rate of the economy as follows. From the population evolution equations (8) and (9), we have

$$n=\frac{n^RN^R+n^UN^U}{N^R+N^U}=n^R\frac{N^R+\dfrac{N^U}{(1+\Phi)}}{N^R+N^U}=n^R\frac{\dfrac{N^R}{N^U}+\dfrac{1}{(1+\Phi)}}{1+\dfrac{N^R}{N^U}}. \tag{18}$$

The first equality highlights the fact that the total population growth rate is a simple weighted average of regional population growth rates. Equation (18) also points out that the total population growth rate is increasing in the rural income to childrearing cost ratio via n^R (income effect) and the rural-urban population ratio (fertility base effect), but decreasing in the rural-urban fertility differential (urban childrearing cost-premium effect). Finally, we define migration intensity as the migration flow divided by the rural population:

$$m\equiv\frac{M}{N^R}=\frac{N_t^R}{N_{t+1}^R}\left(1+n^R\right)-1. \tag{19}$$

Next, we note that

$$nN_{t+1} = n^R N_{t+1}^R + n^U N_{t+1}^U$$

$$\left(n - n^U\right)\frac{N_{t+1}}{N_t}\frac{N_t}{N_t^R} = \left(n^R - n^U\right)\frac{N_{t+1}^R}{N_t^R},$$

or

$$\frac{N_t^R}{N_{t+1}^R} = \frac{n^R - n^U}{\left(n - n^U\right)(1+n)}\frac{N_t^R / N_t^U}{1 + N_t^R / N_t^U}.$$

Substituting this relation into (19), we get migration intensity as follows:

$$m = \frac{\left(n^R - n^U\right)\left(1 + n^R\right)}{\left(n - n^U\right)(1+n)}\frac{N^R / N^U}{1 + N^R / N^U} - 1. \tag{20}$$

Equations (18) and (20) are the key equations for our policy insights on internal migration (m) and fertility (n). While equation (18) focuses on the total fertility rate, equation (20) shows that migration flow affects the migration intensity (m) via two channels: directly through N^R/N^U (the population base effect) and indirectly through n (the population growth effect).

To proceed further, we restrict our attention to a balanced-growth spatial equilibrium (BGSE), where all the growth rates of the level variables are constant. It should be noted that Liao et al. (2019) study the dynamics around the BGSE, thereby enabling a full characterization of the effects of an advance in urban TFP relative to rural TFP. Nonetheless, such dynamic effects turn out to depend on the elasticities that measure the responsiveness of the fertility base and urban childrearing cost, leading to rich outcomes but further complexity. Under the concept of BGSE frequently used in endogenous growth theory, we are able to circumvent such complexity. Accordingly, our aim is to obtain the effects of an improvement in urban TFP relative to rural TFP (a rise in A^U) on migration intensity (m) and the total fertility rate (n).

Consider that δ_i follows a uniform distribution over a compact support $[0,\bar{D}]$, so the density is $1/\bar{D}$. Denote the two gaps as $g_A = A^U/A^R$ and $g_\phi = \phi^U/\phi^R$ and rewrite (15) in dynamic form:

$$\delta_{i^*,t} = (1+\beta)\ln(\alpha) + (1+\beta)\ln\left(g_{A,t}\right) - \beta\ln\left(g_{\phi,t}\right)$$

$$\delta_{i^*,t-1} = (1+\beta)\ln(\alpha) + (1+\beta)\ln\left(g_{A,t-1}\right) - \beta\ln\left(g_{\phi,t-1}\right).$$

Taking differences, we get

$$\delta_{i^*,t} - \delta_{i^*,t-1} = (1+\beta)\ln\left(1+\gamma_{A,t}\right) - \beta\ln\left(1+\gamma_{\phi,t}\right),$$

where

$$1 + \gamma_{j,t} \equiv \frac{g_{j,t}}{g_{j,t-1}}, j = A, \phi$$

denote the growth rate of variable j. As a result, the rural-urban migration flow can be solved as follows:

$$M_t = \frac{1}{\bar{D}}\left(\delta_{i^*,t} - \delta_{i^*,t-1}\right) = \frac{1}{\bar{D}}\left[(1+\beta)\ln\left(1+\gamma_{A,t}\right) - \beta\ln\left(1+\gamma_{\phi,t}\right)\right].$$

Recalling (14), we get

$$\frac{n^R}{n^U} = 1 + \Phi = \frac{g_{\phi,t}}{\alpha g_{A,t}} \equiv \frac{g_t}{\alpha}.$$

At the BGSE, we have constant growth rates so that the $g_{\phi,t}/g_{A,t}$ ratio must be constant; that is, $g_t = g$ or

$$\gamma_{A,t} = \gamma_{\phi,t} = \gamma.$$

This in turn yields

$$M_t = \frac{1}{\bar{D}}\ln\left(\frac{g_{A,t}}{g_{A,t-1}}\right) = \frac{1}{\bar{D}}\ln(1+\gamma) > 0.$$

As a result, (8) and (9) imply a fall in N^R/N^U. Suppose we consider a continuous increase in urban TFP A^U. Under the restriction of BGSE, it also leads to a proportional increase in ϕ^U. Then neither n^R nor $(1+\Phi)$ is affected, so its effect on the total fertilicy rate n works only through N^R/N^U. This is the fertility base effect that we highlight in (18):

$$\frac{\partial n}{\partial A^U} = \underbrace{\frac{\partial n}{\partial\left(N^R/N^U\right)}}_{fertility-base,+}\underbrace{\frac{\partial\left(N^R/N^U\right)}{\partial A^U}}_{-} < 0.$$

According to (18), a rise in A^U increases the urban migration flow, lowers the rural-urban population ratio, and hence lowers the total fertility rate due to the fertility base effect. Thus an ongoing increase in the urban-rural TFP gap reduces the urban fertility rate. The decrease in the urban fertility rate then increases migration intensity indirectly, as shown in equation (20).

We are now prepared to establish the key results of our model based on (20). Consider a long-term trend of structural transformation driven by an ongoing increase in the urban-rural TFP gap A^U/A^R, which is the primary force of the *second nature of geography* that leads to spatial agglomeration (see Cronon, 1991, and survey articles by Berliant and Wang, 2004 and 2019). From (13), (14), (17), one can see that the urban-rural wage ratio (w^U/w^R), the urban-rural fertility differential (n^U/n^R), and the urban-rural per capita income ratio (y^U/y^R) all rise unambiguously. In spatial equilibrium, the SEC in (15) suggests that a higher urban-rural TFP gap raises the disutility cutoff, thereby encouraging more internal migration from the rural to the urban area. As a result, there is a reduction in the rural-urban population ratio N^R/N^U, which generates the two main effects on migration intensity given by (20). On the one hand, the fall in the rural-urban population ratio lowers the migration intensity via the population base effect. On the other hand, it reduces the fertility base and suppresses the total fertility rate, leading to higher migration intensity via the population growth effect. If the direct population base effect dominates the indirect population growth effect, then (20) yields a positive relation between rural-urban migration and fertility. In particular, the ongoing increase in the urban-rural TFP gap (A^U/A^R) yields both low migration intensity and a low total fertility rate thereby lending theoretical support to the empirical correlation between the two measures.

Intuitively, the effect of a rise in urban TFP on the total fertility rate can be observed in equation (18). First, the income effect results in an increase in urban fertility. However, the urban childrearing cost (as a percentage of income) also increases as urban TFP rises. If the later effect dominates the income effect, urban fertility declines. Second, other things equal, a higher urban wage (due to a rise in urban TFP) induces a shift of the population from the rural to the urban area. Because migrants' fertility is on average lower than that in their original area, total fertility falls. Therefore, a rise in urban TFP leads to a lower total fertility rate. We further use equation (19) to provide the intuition for the overall effect on migration intensity. A rise in urban TFP results in rural-urban migration, so the rural population falls. Given the same migration flow, a lower rural population leads to higher migration intensity. However, a smaller rural population also implies fewer migrants and hence lowers migration intensity. When the later effect dominates, a rise in urban TFP reduces migration intensity. In summary, our result indicates a positive relation between migration intensity and the total fertility rate as urban TFP rises.

Our finding implies that policies that may help reduce the cost of urban living or enhance urban benefits would be useful for productive structural transformation. Such policies include the following: (i) a subsidy for urban childrearing, including provision of low-cost public daycare, (ii) a subsidy for new rural-urban migrants, including public housing assistance, and (iii) better provision of urban benefits to all residents.

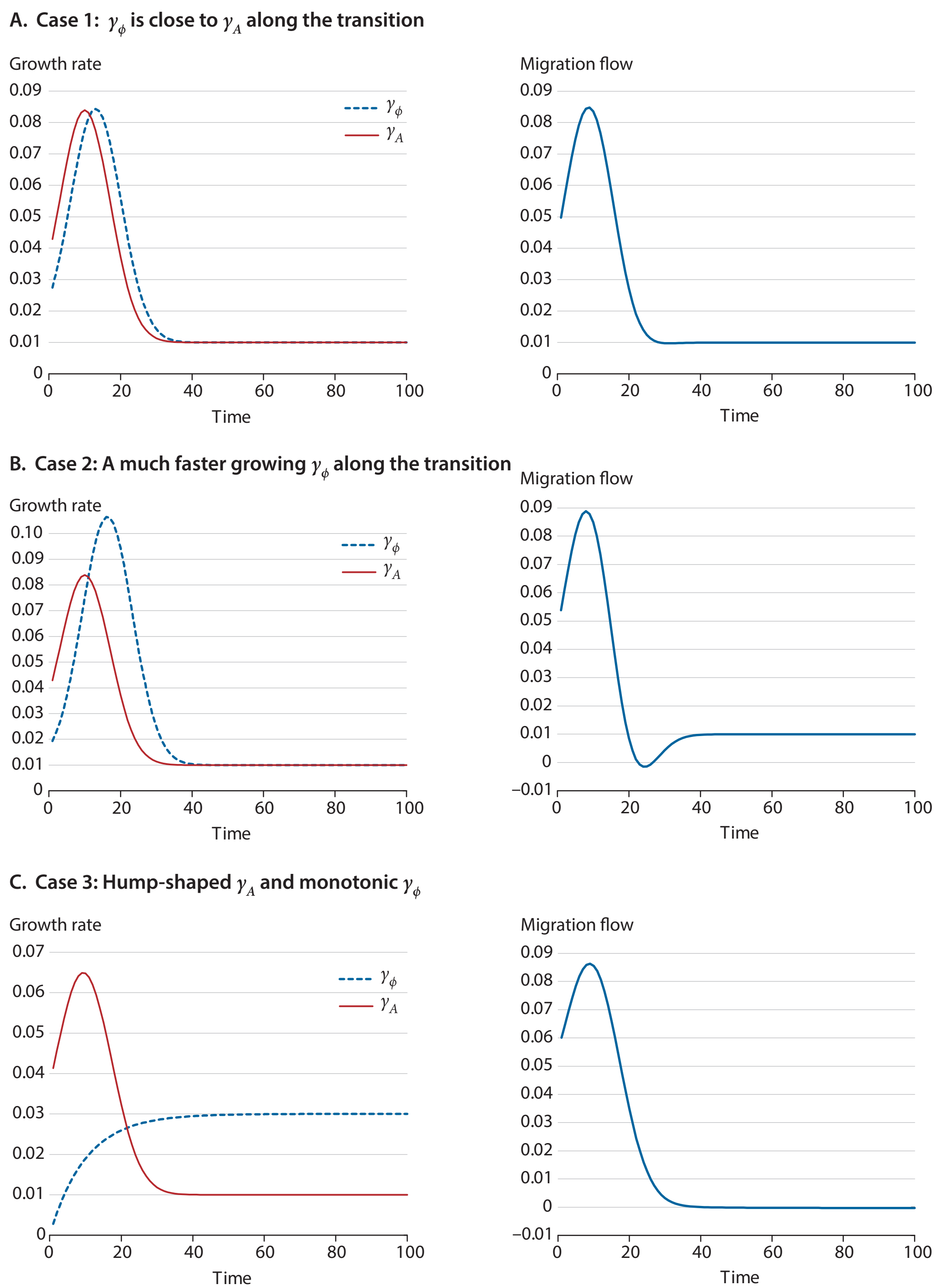
But when might this internal migration cease? To address this question, we further examine (15). Let $\delta_{\min}$ be the minimum support of the stationary distribution of δ_i; that is, $\delta_{\min} \equiv \inf \delta_i < \delta_{i^*}$. Then, internal migration ceases when

$$\beta \ln\left(\phi^U/\phi^R\right) > (1+\beta)\ln(\alpha) + (1+\beta)\ln\left(A^U/A^R\right) - \delta_{\min},$$

which would happen when urban childrearing becomes unaffordable. That is, a rising urban childrearing cost relative to the rural childrearing cost serves as an anti-agglomeration force in our economy, without any need for other drivers. This complements the literature well. For example, in Lucas (2004), the anti-agglomeration force is rising rural productivity because land is a specific factor only for rural farming. In Sato (2007), the anti-agglomeration force is urban congestion. In Bond, Riezman, and Wang (2016), the anti-agglomeration force is the balance in capital usage between the import-competing and the exporting sectors. In Liao et al. (2020), the anti-agglomeration force is the balance between earnings and child preferences in the presence of heterogeneous altruism. In Garriga et al. (2017), the anti-agglomeration force is housing price hikes. In this article, were we to consider additional spatial diseconomies forces, either internal (say, due to social decreasing returns) or external (say, due to a congestion externality), it is clear that the internal migration process would slow down and rural-urban migration would cease sooner.

Figure 2

Growth Paths of Relative TFP, Relative Childrearing Costs, and Migration Flows



6 NUMERICAL EXAMPLES

In addition to characterizing BGSE theoretically, we provide three useful numerical examples to illustrate the transitional dynamics for the rural-urban migration flow, M_t. In all cases, we begin with setting artificial growth paths for A and ϕ. Given the growth paths of A and ϕ and the parameters $\bar{D} = 1$ and $\beta = 0.52$, we are able to compute the migration flow M_t, which may be called migration intensity with a unit mass of total population. The growth paths of A and ϕ governed by γ_A and γ_ϕ, respectively, and the corresponding migration flows for all three cases are provided in Figure 2.[6] One model period is equal to one year in the numerical examples.

The three cases begin with the same assumption that the initial growth rate of A is higher than that of ϕ, $\gamma_{A,0} > \gamma_{\phi,0}$. Then, along the transition, the paths of γ_A and γ_ϕ are all different. The first two cases consider a path where γ_A and γ_ϕ are both hump-shaped and asymptotically approach 1 percent in the BGSE. In particular, in the second case, γ_ϕ grows faster than γ_A in the transition, whereas in the first case, the path of γ_ϕ is close to that of γ_A. In the third case, γ_A remains hump-shaped, approaching 1 percent asymptotically, but γ_ϕ rises monotonically to 3 percent asymptotically.

We find that, in all three cases, the transitional dynamics of the migration flows are nonmonotone. The migration flows in the first two cases peak at around 8 to 9 percent, before reducing to the long-run BGSE level. In addition, in both cases, it takes more than four decades for the migration flows to reach the BGSE level. However, in the second case, because γ_ϕ rises much faster than γ_A, the migration flow does not fall monotonically from the peak to the BGSE level as the first case does. As shown in Figure 2, in the second case, the migration flow overshoots downward from the peak and then moves up toward the BGSE level. In the third case, γ_ϕ rises much faster to an asymptote higher than γ_A and as a result migration ceases after 41 years, yielding a degenerate BGSE.

7 THE WAY FORWARD

In this article, we have developed a simple dynamic model of fertility and internal migration. We have provided conditions to show that, as urban TFP progresses, migration and fertility co-move. Our cross-country data analysis has suggested that migration intensities and total fertility rates are indeed higher in less-developed countries and lower in advanced economies.

Such a dynamic interplay between fertility and migration is interesting, as it can generate a vicious cycle in economic development. Specifically, in a poor country with low manufacture productivity, the total fertility rate is high, due primarily to the rural fertility rate. Without a technology push from the urban modern sector, the economy remains mired in a Malthusian trap. With sufficient technology advancement, however, the incentive to migrate to urban areas rises, starting the urbanization process and raising the urban population. Because fertility rates of urban residents are lower than those of rural farmers, the total fertility rate starts to drop. With the urban cost of living rising over time, the migration rate starts to fall. Thus, the advancement of urban productivity in conjunction with the interplay between fertility and migration can pull a poor country out of a Malthusian trap (a high fertility-migration nexus) toward modernization (a low fertility-migration nexus). Policies that help reduce rural-urban migration costs may serve the same purpose. In short, rural-urban migration enables a less-developed country to be transformed from Malthus to Solow.

While a simple fertility choice and locational choice framework has been successful in delivering a positive relationship between fertility and rural-urban migration, one may wonder why the relationship between migration intensity and relative income is weaker than that between total fertility and relative income and why both relationships are weakened when relative income is measured by the final value rather than the initial value over the same period. These remain unanswered.

In our work in progress, Liao et al. (2019), we use a richer framework in which households also value children's education outcomes and their futures. In that framework, we are able to partially address the above unexplored issues by analyzing the dynamic progress of structural transformation. Regardless, we judge that the existing theory lags behind the empirics, particularly in characterizing the long process of demographic transition accompanied by a fairly rapid process of urbanization over the past half a century. It is our belief that addressing these issues would be potentially rewarding. ■

NOTES

1 As to be discussed in the literature review, there are very few studies connecting fertility and migration in a dynamic setting.

2 Based on a multivariate ordinary least-squares regression analysis on the data from the China Urban Labor Survey of 2001, Werwath (2011) discovers that migrants generally have higher fertility than native urban residents. Thus, there is little doubt that migration and fertility are closely connected.

3 Crude migration intensity of major areas measures the migration between the first subnational geographic levels, such as provinces, out of all of the population 15 years of age and above.

4 In the endogenous fertility literature, there are other ways to model the number of children desired. For example, the dynasty model in Barro and Becker (1989) consider children's value and Glomm and Ravikumar (1992) value children's human capital or income in fertility choices. Bloom et al. (2009) develop an endogenous fertility model with a representative female who values the quantity (number) of children but not their quality (education or human capital). Our setup is close to theirs, though our utility function is simply the log-transformation version of that in Sato (2007).

5 This functional form implies that there exists rent, which is assumed to be used to pay for government infrastructure (or given to an absentee landlord), as typically assumed in urban economics. We do not intend to analyze it, because conducting welfare analysis is not the purpose of this article.

6 The three paths of γ_A and γ_ϕ are given by

$$\text{Case 1}: \begin{cases} \gamma_A = 0.01 \cdot \left[1+\exp\left(1+0.2\cdot t-0.01\cdot t^2\right)\right] \\ \gamma_\phi = 0.005\cdot\left[2+\exp\left(1+0.26\cdot t-0.00995\cdot t^2\right)\right] \end{cases},$$

$$\text{Case 2}: \begin{cases} \gamma_A = 0.01 \cdot \left[1+\exp\left(1+0.2\cdot t-0.01\cdot t^2\right)\right] \\ \gamma_\phi = 0.0025\cdot\left[4+\exp\left(1+0.325\cdot t-0.00995\cdot t^2\right)\right] \end{cases},$$

$$\text{Case 3}: \begin{cases} \gamma_A = 0.01 \cdot \left[1+\exp\left(1+0.15\cdot t-0.008\cdot t^2\right)\right] \\ \gamma_\phi = 0.03\cdot\left[1-\exp\left(-0.1\cdot t\right)\right] \end{cases}, \text{ respectively.}$$

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