CESifo WORKING PAPERS

9338
2021

October 2021

Population Sorting and Human Capital Accumulation

Leonid V. Azarnert

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 9338*

Population Sorting and Human Capital Accumulation

Abstract

This article analyzes the effect of population sorting on economic growth. The analysis is performed in a two-region growth model with endogenous fertility, in which public knowledge spillovers from the more advanced core into children's human capital accumulation function in the periphery are incorporated. I show how migration affects the inter-temporal evolution of human capital in each of the regions and the economy as a whole. I also discuss how public policy interventions can help increase the per-capita human capital levels, if free uncontrolled migration leads to a reduction in human capital accumulation.

JEL-Codes: D300, J100, O150, O180.

Keywords: migration, population sorting, knowledge spillovers, fertility, human capital, economic growth.

Leonid V. Azarnert
Department of Economics
National Research University Higher School of Economics
3A Kantemirovskaya St.
Russia – St. Petersburg, 194100
Leonid.Azarnert@gmail.com

1. Introduction

Using a two-region overlapping generation (OLG) model with endogenous fertility and human capital accumulation, this paper studies the effect of population sorting on economic growth. I show that free migration can be growth enhancing or growth depleting and consider public policy interventions to mitigate a possible negative effect. The novelty of the paper is introducing public knowledge spillover effect from the more advanced core into children's human capital accumulation function in the periphery, while considering the causes and consequences of individual residential choice for each of the regions and the economy as a whole.

Spillover effects of locally produced knowledge and technology diffusion have long been widely documented in a vast empirical literature.[1] Studying technology diffusion, scholars usually observe that there is more within- than between-country diffusion, and that the benefits from spillovers decline with distance (Jaffe et al., 1993; Jaffe and Trajtenberg, 1999; Keller, 2002). Predictably, researchers also find that a common official language (McGarvie, 2005), technological (Autant-Bernard and Lesage, 2011), relational (Amin and Cohendet, 2004) and social (Singh, 2005; Gomes-Casseres et al., 2006) proximity, and absorptive capacity (Cohen and Levinthal, 1989) greatly facilitate knowledge spillovers. For international knowledge flows, it has been often assumed that there exists an international stock of knowledge, created by the main innovative countries, upon which every country can draw (Hu and Jaffe, 2003), which generates an obvious core-peripheral structure of knowledge production and diffusion (Chen and Guan, 2016). It has also been shown that, across subnational regions, knowledge flows emanating from a small number of technological leaders are much less geographically localized and, therefore, may act as leading learning sources for other regions (Peri, 2005). This provides a foundation for a policy recommendation to help attain and reinforce innovative excellence in a few leading regions, from which knowledge would then spill over to less innovative regions (Anant-Bertrand et al., 2013). The mechanism of knowledge spillover from the core region to the periphery exploited in the present work is close in spirit to this model of knowledge creation-dissemination.

[1] See, for example, Coe et al. (1997) on North-South R&D spillovers, Coe et al. (2009) on R&D spillover among OECD countries and Keller (2004) on international technology diffusion in general.

A negative effect of the geographical concentration of economic agents in smaller, densely populated areas has long been well recognized in urban and regional economics and new economic geography. Thus, for example, according to Henderson (2002), United Nations Center for Human Settlements (UNCHS) data indicate that, typically around the world, moving from a city of 250,000 to one of 2.5 million is associated empirically with an 80 percent increase in housing rental prices and commuting times. According to Au and Henderson (2006), the UNCHS data for 1996 on world cities also suggest that about 15% of work time is spent just on the commuting to work trip. Liu et al. (2018) report that a typical tenant in a tall commercial building in the US spends 22.36 minutes a day waiting for or riding elevator – about the same time as an average one-way commute to work. Richardson (1987) argues from data for four developing countries that moving from a small city to a megacity raises per capita investment costs per family in urban infrastructure by threefold. Using French data, Combes et al. (2019) demonstrate that the share of income devoted to housing increases significantly with population, from about 16 percent in a city with 100,000 inhabitants to 39 percent in a city like Paris. Detailed arguments can be found, for instance, in Kanemoto (1980) and Fujita (1989).

This negative effect referred to as "congestion diseconomies", or "congestion costs" has been exploited in a large number of theoretical contributions, such as, for instance, Tabuchi (1998), Duranton and Puga (2004), Sato and Yamamoto (2005), Venables (2005), Henderson and Wang (2005), Sato (2007), Henderson and Venables (2009), Desmet and Rossi-Hansberg (2013), Azarnert (2019), and Albouy et al. (2019), among others. To model congestion, researchers usually assume that all production in a city occurs in a Central Business District (CBD). Surrounding the CBD there is a circle of residences, owned by absentee landlords, where each worker occupies one unit of land. This creates a per worker cost of urban living, which consists of the cost of commuting to the CBD and land rent. The commuting costs and the land rent are considered to increase with population concentration, which, in turn, reduces the workers' disposable time and income.

Although congestion itself is an intuitive cost of increased population concentration, a stronger and more topical argument can also be made about the provision of public goods in general. Thus, for example, regional scientists have pointed to congestion in the transport infrastructure (rail and roads) for generations. (See, for instance, McCann and Shefer, 2004 where references to the earlier literature can be found.) Similarly, a negative effect of overcrowding has also long been observed in the context of schools (e.g. Jepsen and Rivkin, 2009 and references therein), hospitals (Derlet and Richards, 2000; Schull et al., 2001; Trzeciak and Rivers, 2003; Sprivulis et al., 2006; Richardson and Mountain, 2006, among many others), local police and fire protection (Bruckner, 1981), the provision of public recreation resources, such as parks, trails, and other types of recreational open space (Dahmann et al., 2010), as well as urban crime (e.g. Glaeser and Sacerdote, 1999; Cullen and Levitt, 1999; Gibbons, 2004) and air pollution and noise (Liu et al., 2019 and references therein). In sum, as Barro and Sala-i-Martin (1992) have argued, virtually all public services are characterized by some degree of congestion. With all these arguments in mind, the present paper adopts the approach of the aforementioned urban and regional economics literature and uses the term "congestion" to refer to the costs associated with density.[2] This allows us to concentrate on the pure effect of migration and population concentration on human capital accumulation and avoid discussion of the reasons why government has not invested enough to cope with the increased demand of the larger population.

Studies in urban economics usually consider interplay between the negative congestion diseconomies and positive agglomeration economies. However, in standard models of urban areas (Henderson, 1974; Duranton and Puga, 2004), the allocation of population across locations is stable only if agglomeration effects are offset by congestion or diminishing marginal returns to labor. In the present framework, congestion diseconomies are modeled explicitly, while agglomeration effects are captured by higher wages and returns to investment in human capital in the more advanced and denser populated core relative to the less advanced and less denser populated periphery. For a survey of the literature on the benefits from density and its costs see, for example, Duranton and Puga (2020).

[2] Recent literature on international migration (e.g. Desmet and Rossi-Hansberg, 2015; Docquier et al., 2015; Delogu et al., 2018) has considered congestion associated with the production function, where congestion operates through the diminishing returns to scale due to the existence of a fixed factor of production. This is another form of congestion that can be viewed as complementary to the formulation adopted in the present model. Congestion has also long been a central feature of the theory of clubs (Helpman and Hillman, 1977; Hillman and Swan, 1983).

In this model, an increase in population density is associated with a reduction in fertility. Evidence supporting such a connection abounds (e.g. Murphy et al., 2008; Simon and Tamura, 2009; cf. also Malmberg, 2012 where further references can be found). In theoretical literature with locational choice and congestion diseconomies, a negative effect of population concentration on fertility has been shown in Sato and Yamamoto (2005), Sato (2007) and Azarnert (2019). However, these studies consider only one way of migration: from less advanced and less densely populated areas to more advanced and more densely populated areas, while the first two models also abstract from investment in education and therefore do not consider human capital accumulation, which is the major theme of the present study.

Various aspects of spatial sorting of heterogeneous individuals have been thoroughly studied in a number of important contributions. In earlier work, Abdel-Rahman and Wang (1997) consider the sorting of skilled workers into core cities and that of unskilled workers into peripheral satellite cities, while in More and Turrini (2005) sorting by talent occurs in a two-region setting. In Behrens et al. (2014), the complementarity between talent and city population leads to the sorting of more talented individuals into larger cities where they stand a higher chance of becoming highly productive entrepreneurs. In Davis and Dingel (2019), higher-ability individuals sort into larger cities to benefit from better idea-exchange opportunities, which raise their productivity. In Behrens and Robert-Nicoud (2014), ex-ante identical individuals can move from a rural hinterland to cities, where they benefit from agglomeration, but may get a poor entrepreneurial draw, so that urbanization also generates inequalities. In Eeckhout et al. (2014), skill complementarity in production is the reason why large cities disproportionally attract both high- and low-skilled individuals. On the other hand, Fajgelbaum and Gaubert (2020) argue that the decentralized pattern of sorting may be inefficient and the U.S. economy would benefit from a reallocation of workers to currently low-wage cities.

The present work extends the literature on population sorting in the direction of endogenous fertility and human capital accumulation.[3] The analysis is performed in a

[3] An early work by Eaton and Eckstein (1997) who present a multicity model with migration and human capital spillovers within and across cities can be viewed as a predecessor of the present study. However, a

two-region growth model in the tradition of Galor and Tsiddon (1997) building on Azarnert (2019), where the effect of migration from a less advanced economy to a more advanced economy on economic growth was considered.[4] In this model, besides economic conditions in each region and the cost of migration,[5] individual locational choice is influenced also by fertility consideration, as consistent with vast empirical evidence (Lindgren, 2003; Kulu, 2008; Vidal et al., 2017). The present framework allows us to derive the threshold levels of human capital that divide the indigenous population in each region into two groups: In the periphery, it is the more skilled, for whom migration to the more productive and expensive core is optimal, and the less skilled, for whom migration is not worthwhile. In the core, on the contrary, it is the less skilled, for whom migration to the less productive and cheaper periphery is lucrative, and the more skilled, for whom the optimal strategy is to remain in their native region.

Given the optimal sorting strategy, the unambiguous positive effect of the out-migration on the average level of human capital in the core with the opposite negative effect in the periphery and an uncertain effect of the in-migration that can either increase or decrease the average level of human capital in each of the regions if the migrants, on average, possess more or less skills than the local individuals is not surprising. The major contribution of the present paper in this context is to show that, if the net effect of migration is to increase the average level of human capital in the core, while reducing the average human capital in the periphery, population sorting still can enhance human capital accumulation in the latter, as follows from the spillover effect from the core in the human capital production function in the periphery. This result is opposite of the outcomes in a framework without inter-regional spillovers, where a reduction in the average human capital within the local society necessarily reduces the productivity of the learning

modeling strategy of the present paper differs significantly from that of Eaton and Eckstein who assume that individuals are homogeneous and population in every city grows at a common exogenously given rate, work with a representative resident in each city and predict that each individual's level of human capital in every city converges to the citywide average, and, in the steady-state, all cities grow at a common growth rate.

[4] For surveys of the literature on endogenous fertility and growth, see Galor (2011, 2012). Other works in this context to which the present model is connected include Mountford (1997), Dahan and Tsiddon (1998), Galor and Moav (2000, 2002), Moav (2005), Tamura (2006), Galor and Mountford (2008), Azarnert (2008, 2012, 2016), Mountford and Rapoport (2011), Tamura and Cuberes (2020), and Hiller and Toure (2021).

[5] The cost of migration can be substantial. Thus, for example, for US interstate migration, Bayer and Juesson (2012) obtain a cost estimate close to US$ 35,000 or roughly two thirds of an average annual household income.

technology, via a local regional human capital externality, and may even lock the society in a low equilibrium poverty trap.

In this paper, I show how migration affects the inter-temporal evolution of human capital and derive conditions for migration that takes place in one period of time to increase or decrease the average level of human capital in each of the regions and the economy as a whole in the next period and further on. Next, I discuss how public policy interventions can help increase the per-capita human capital levels, if free uncontrolled migration leads to a reduction in human capital accumulation. The present analysis also suggests that, for a developed society that values not only human capital accumulation, but also higher reproduction rates, an easy way to stimulate both of them simultaneously could be to encourage some net out-migration of the lower-skilled individuals from the densely populated core to the less populated periphery.[6]

The former Soviet *propiska* and Chinese *hukou* systems designed to discourage rural-urban migration and entry for lower skilled individuals into the major most desirable cities, which drive economic growth in the country, would perhaps appear as primary examples of centralized public migration policies implemented at a state level for a long period of time. But other countries, such as, for example, Egypt, Brazil, Korea, and Mexico, also over the years pursued medium size city policies designed to forestall the growth of bigger cities (Henderson, 1988, 2003). To deter low-skilled in-migration at a local level, localities in developed countries often enact regulations to make these locations prohibitively expensive for poorer in-migrants (Glaeser et al., 2005; Hilbert and Robert-Nicoud, 2013), while localities in developing countries may strategically withhold public services to the informal housing sector to make living conditions for informal sector residents more difficult and discourage further in-migration of the types of people likely to occupy these areas (Feler and Henderson, 2011). In China, this strategic component of withholding services is explicitly articulated in policy design (Cai, 2006) and continuously practiced to the present (Chen et al., 2017). Superstar cities, which restrict development, experience much slower growth in the number of their inhabitants and increases in their share of the population from the high-income groups, as high-income in-migrants outbid and drive out the poorer residents (Gyourko et al., 2013). The present analysis contributes to a better understanding of the conditions that a properly designed migration policy is required to satisfy to enhance human capital accumulation and hence economic prosperity not only in the protected locations, but in the economy as a whole. Also, public policy interventions considered in this paper are based on purely economic mechanism and do not require complicated regulations or strategic discrimination.

Motivated by rapid urban expansion in the developing world (Glaeser, 2014) that has often occurred in the face of low or negative economic growth over decades (Henderson, 2003), growing recent literature has provided various explanations for the observed “urbanization without growth” (Jedwab et al., 2017; Castelles-Quintana, 2017; Jedwab and Vollrath, 2019 and references therein). By showing how uncontrolled lower skilled migration from the periphery may inhibit human capital accumulation in the more urbanized core, thereby adversely affecting the prospects for economic growth in the whole economy, the present work also provides additional insight into this phenomenon.

2. The Basic Structure of the Model

Consider an overlapping-generations economy, in which activity extends over an infinite discrete time. In every period the economy produces a single homogenous good using a constant-returns-to-scale (CRS) technology with human capital as the only input. In each generation, agents live for two periods: childhood and adulthood. During childhood, individuals acquire human capital. During adulthood, they work, become parents and bring up their offspring. As parents, adult individuals allocate a positive fraction of their time to feeding and raising their children and invest in the education of their children.

Suppose an economy that consists of two entities: a more advanced and more urbanized core region denoted by C, and a less advanced and less urbanized peripheral region denoted by P. For some exogenous reason, in the more advance core wages, the

[6] For a less developed economy that does not aim to increase population growth, such policies could be supplemented with an additional intervention so as to increase the cost of child quantity, as has long been suggested in the growth literature (Moav, 2005; Azarnert, 2010a).

average level of human capital and population density are higher than those in the less advanced periphery.

Also suppose that in the beginning of the second period of life, young adult individuals can migrate from one region to the other. If young adults migrate, they work, become parents, bring up and educate their children at their destination.

2.1. The formation of human capital

In any period t, an adult born in region i $(i = C, P)$ is characterized by a skill level h_t that is distributed according to the cumulative density function $F_t(\cdot)$ over the strictly positive support $[h_t^{\min}, h_t^{\max}]$. It is assumed throughout that in period t, the average level of human capital in the more advanced core is higher than that in the less advanced periphery; $\bar{h}_t^C > \bar{h}_t^P$.

In each period of life, individuals are endowed with one unit of time. In the first period, children devote their entire time to the acquisition of human capital. The acquired human capital increases if their time investment is supplemented with real resources invested in their education.

The human capital level of a child, who becomes an adult in period $t+1$, depends on the parental real expenditure on that child's education, e_t, and on the average level of human capital of all adult individuals in economy in period t, such that in the more advanced core region it depends on that region's average level of human capital in parental generation, which is defined as $\bar{h}_t^C = \int h_t dF_t^C(h^C)$, while in the less advanced periphery it depends on both that region's own average level of human capital, $\bar{h}_t^P = \int h_t dF_t^P(h^P)$, and the core region's average level of human capital, $\bar{h}_t^C$, according to the human capital production function, or learning technology described by

$$h_{t+1}^i = \begin{cases} \Theta(e_t, \bar{h}_t^i), & \text{if } \ i = c, \\ \Theta(e_t, \bar{h}_t^i, \bar{h}_t^C), & \text{if } \ i = p. \end{cases} \tag{1}$$

This learning technology captures an external spillover effect that arises from the average society's level of human capital, $\bar{h}_t$. Such formulation is consistent with the socalled global or atmospheric externality, which implies that an increase in the average level of human capital in the society as a whole increases the rate of return on investment in human capital for the children's generation. First introduced by Tamura (1991), the assumption that the average level of human capital in society is an input in the production of human capital for each individual became common in the literature. This externality has been utilized, for instance, by Tamura (1996), Galor and Tsiddon (1997), Morand (1999), de la Croix and Doepke (2003, 2004), Henderson and Wang (2005), Viaene and Zilcha (2009), Aksan and Chakraborty (2014), and Azarnert (2018, 2020), among many others.

The novelty of the present work relative to the aforementioned studies is that, in this model, I consider two types of the spillover effects. First, a local regional human capital externality operates in each of the regions, as in the previous literature. Second, I assume the existence of an additional inter-regional knowledge spillover effect from the more advanced core to the periphery, as consistent with empirical evidence discussed in the introduction.

A particular form of human capital production function is specified below in equation (7).

2.2. Congestion diseconomies and the cost of migration

Suppose that in either region $(i = C, P)$, an adult individual incurs the basic cost of living that includes land rent, i.e., the costs of living space rented from the absentee landlords, who keep their rental revenues "outside the model", and commuting costs to the business district for work and shopping and to the recreational area for relaxation. These costs represent congestion diseconomies, as is commonly assumed in the urban economics literature (e.g. Kanemoto, 1980; Fujita, 1989; Tabuchi, 1998; Sato and Yamamoto, 2005; Venables, 2005; Henderson and Wang, 2005; Sato, 2007; Henderson and Venables, 2009; Desmet and Rossi-Hansberg, 2013; Azarnert, 2019; Albouy et al., 2019, among others). Furthermore, as consistent with the aforementioned urban economics literature, it is assumed that the costs of congestion diseconomies increase with population density, which implies that an increase in the population size in any region reduces each individual's disposable income in that region.

More specifically, the basic cost of living, or congestion diseconomies, is assumed to be a positive, strictly increasing function of the size of adult population in region i, L_t^i:

$$\Omega_t^i = \Omega^i(L_t^i), \quad \text{where } \forall L_t^i \geq 0, \;\; \Omega^i(L_t^i) \geq 0, \;\; \Omega'(L_t^i) > 0, \;\; i = C, P. \tag{2}$$

A particular form of congestion costs function is specified below in equation (B1).

We also assume that in period t, in the more urbanized and hence more densely populated core the costs of congestion are higher than those in the less urbanized and less densely populated peripheral region; $\Omega_t^C > \Omega_t^P$.

To complete the description of the economy, we suppose that a young adult individual born in the periphery, who migrates in period t to the core, must pay the amount M_t^{PC} that covers the costs of migration. Similarly, a young adult, who migrates from the core to the periphery, pays the amount M_t^{CP}. We also assume that migration involves no losses of human capital, so that any unit of human capital acquired in the home region prior to migration is as productive as the skills acquired in the destination region.

Since by construction in this model, two ways of migration can be worthwhile, in the economy under consideration there are potentially four types of individuals: (1) C, individuals born in the core, who remain in their native region, (2) P, individuals born in the periphery, who remain in the region where they were born, (3) PC, individuals born in the periphery, who migrate to the core, and (4) CP, individuals born in the core, who migrate to the periphery. The conditions that lead to the decision to migrate are analyzed below in Section 2.5.

2.3. The optimization of parents

Agents of any type derive utility from their own consumption in adulthood and from the total future income of their children in the region where the children were born.[7] The

[7] This assumption rules out the situation when parents, who do not find it worthwhile to migrate, will consider the possibility of migration for their offspring. This anticipates the further assumption (Section 2.6) that migration is possible in period t only. Assuming that parents take the possibility of their offspring's migration into account will change the threshold levels of human capital, which separate agents who migrate from those who remain in their regions of birth, without altering the qualitative nature of this paper's results.

utility function of an individual of any type j ($j = C, P, PC, CP$) born at time $t-1$ is therefore

$$U_t^j = (1-\beta)\log C_t^j + \beta \log(I_{t+1}^{N,j}), \qquad (3)$$

where C_t^j is an individual's own consumption, $I_{t+1}^{N,j}$ is the future income of that individual's offspring and $\beta \in (0,1)$ captures the relative weight given to children.[8]

In every period *t*, adult individuals are endowed with one unit of time which is allocated between childbearing and labor force participation. From their labor income all individuals pay the costs associated with congestion diseconomies in their region of residence, Ω_t^i, and individuals, who migrate from one region to the other, pay the costs of migration, M_t^{PC} and M_t^{CP} , respectively. In either region, the cost of feeding and raising children is measured in terms of work time foregone at δ per child. The cost of acquiring human capital in any region i is measured in units of the wage per efficiency unit of labor in that region, w^i. In either region, the wage per efficiency unit of labor, w^i, is fixed over time, as follows from, for instance, the assumption of a CRS technology with a single factor of production.

Individuals are assumed to behave as atomistic agents, so that the migrants neglect the effect of their migration on the basic cost of living, Ω_t^i, and the average levels of human capital, $\bar{h}_t^i$, in the regions of their origin and destination. Similarly, all agents neglect the effect of their decision with respect to the number and qualilty of their offspring on the basic cost of living and the average level of human capital in the next generation.

To maximize utility, an adult of any type j simultaneously chooses a current consumption, C_t^j, the number of children, N_t^j, and invests e_t^j units of w^i in each child's education subject to the following budget constraint:

$$C_t^j + w^i(\delta h_t + e_t^j)N_t^j \le w^i h_t - \Omega_t^i, \qquad \text{if } \begin{cases} j = i = C, \\ j = i = P, \end{cases}$$

8 In the utility function postulated by Galor and Moav (2002) individuals differ with respect to the relative weight given to the quality of their children. In the utility function used in Azarnert (2010b), where the choice is between giving birth to one child per parent or remaining childless, individuals differ with respect to the weight given to the child.

$$C_t^j + w^i(\delta h_t + e_t^j)N_t^j \le w^i h_t - \Omega_t^i - M_t^j, \quad \text{if } \begin{cases} j = PC \text{ and } i = C, \\ j = CP \text{ and } i = P. \end{cases} \tag{4}$$

The right-hand side of equation (4) represents an adult's income net of the costs associated with congestion diseconomies for all individuals and migration for agents who relocate from one region to the other, which is allocated between consumption and the total cost of rearing children.

The total potential future income of that individual's offspring is:

$$I_{t+1}^{N,j} = N_t^j h_{t+1} w^i, \quad \text{if } \begin{cases} j = C, PC, \ i = C, \\ j = P, CP, \ i = P. \end{cases} \tag{5}$$

The next subsection discusses the solution for the parents' optimization problem for a particular form of the human capital production function.

2.4. Choice of fertility and investment in education

From optimization, an adult's consumption is:

$$C_t^j = (1-\beta)\begin{cases} w^i h_t - \Omega_t^i, & \text{if } \begin{cases} j = i = C, \\ j = i = P, \end{cases} \\ w^i h_t - \Omega_t^i - M_t^j, & \text{if } \begin{cases} j = PC \text{ and } i = C, \\ j = CP \text{ and } i = P. \end{cases} \end{cases} \tag{6}$$

That is, a fraction $1-\beta$ of an adult's full income net of the costs associated with congestion diseconomies and migration is devoted to consumption and hence a fraction β is devoted to childrearing.

To characterize optimal choices of fertility and investment in education, suppose that in either region all children born in this region have access to the same technology of human capital production:

$$h_{t+1} = A(\mu + e_t^j)^\gamma \begin{cases} (\bar{h}_t^i)^{1-\gamma}, & \text{if } j = C, CP, \ i = C, \\ (\psi \bar{h}_t^i + (1-\psi)\bar{h}_t^C)^{1-\gamma}, & \text{if } j = P, PC, \ i = P, \end{cases}$$

where $A > 1$, $\mu > 0$, $0 < \gamma < 1$, and $0 < \psi < 1$. (7)

This learning technology implies that the average level of human capital in the more advanced core region is an input in the production of human capital for the children's generation also in the less advanced peripheral region, as has been discussed above in Section (2.1). It also implies that children of the migrants from the peripheral/ core region born in the core/ periphery become similar to the offspring of the indigenous C - and P -type individuals, respectively.

Given (7), the optimal choice of investment in the children's education of an individual of any type in either region is:[9]

$$e_t^j = \frac{\gamma\delta h_t - \mu}{1-\gamma} \ , \quad j = C, P, PC, CP, \tag{8}$$

so that, according to (8),

$$h_{t+1} = A\left(\frac{\gamma}{1-\gamma}(\delta h_t - \mu)\right)^{\gamma} \begin{cases} (\bar{h}_t^i)^{1-\gamma}, & \text{if } \ i = C, \\ (\psi\bar{h}_t^i + (1-\psi)\bar{h}_t^C)^{1-\gamma}, & \text{if } \ i = P. \end{cases} \tag{9}$$

Given the amount of resources allocated to children's education, the desired fertility for agent of any type is:[10]

$$N_t^j = \frac{\beta(1-\gamma)}{\delta - \dfrac{\mu}{h_t}} \begin{cases} 1 - \dfrac{\Omega_t^i}{w^i h_t}, & \text{if } \begin{cases} j = i = C, \\ j = i = P, \end{cases} \\ 1 - \dfrac{\Omega_t^i + M_t^j}{w^i h_t}, & \text{if } \begin{cases} j = PC, \ \ i = C, \\ j = CP, \ \ i = P. \end{cases} \end{cases} \tag{10}$$

Equation (8) shows that the optimal choice of investment in the offspring's education and hence the children's human capital levels (Eq. 9) is positively related to the parent's human capital, although parental human capital does not enter the learning technology directly. Equation (10) demonstrates that the optimal choice of fertility is negatively related to the costs associated with congestion (Ω_t^i) and migration (M_t^{PC} and M_t^{CP}).

In the next section, I derive conditions that lead to the decision to migrate.

2.5. The decision to migrate

To characterize individual choice with respect to migration, recall that by definition in this model period *t* the average level of human capital in the core is higher than that in the

---

[9] An assumption that $h_t^{\min} > \mu/\gamma\delta$ ensures that all parents invest in the education of their children.

[10] Notice that as long as $\dfrac{\Omega_t^C}{\Omega_t^P} > \dfrac{w^C}{w^P}$, $N_t^P > N_t^C$, while for any $\dfrac{\Omega_t^C}{\Omega_t^P + M_t^{CP}} > \dfrac{w^C}{w^P}$, $N_t^{CP} > N_t^C$.

periphery; $\bar{h}_t^C > \bar{h}_t^P$. This implies that, as long as the spillover effect of the core region's human capital in the production of human capital in the periphery is smaller than 100% ($\psi > 0$), for any given fraction of the parental income invested in the offspring's education, $e_t w^i$, the human capital production function (7) yields a higher level of the child's human capital in the core. Similarly, the wage per unit of efficiency labor in the core is also higher than that in the periphery; $w^C > w^P$. At the same time, a migrant from the periphery should pay the costs of migration, M_t^{PC}, and bear the costs of congestion that are higher than in his region of origin; $\Omega_t^C > \Omega_t^P$. Therefore, young adult individuals from the periphery decide to migrate if their utility in the case of migration is higher than their utility in their region of birth; $U_t^{PC} > U_t^P$. On the other hand, an agent born in the core could find it worthwhile to relocate to the periphery to conserve on the costs of congestion. Therefore, young adult individuals from the core decide to migrate if their utility in the case of migration to the periphery is higher than that at the origin; $U_t^{CP} > U_t^C$.

Begin with the potential migrants from the periphery to the core. Substituting an individual's own consumption along with the income of the offspring of that individual in the case of migration to the core, as shown in equations (6) and (5), respectively ($j = PC$), into the utility function (3) and comparing the result to the level of utility in the case of no migration ($j = P$) allows us to compute the threshold level of human capital for the population in the periphery:[11]

$$\hat{h}_t^{PC} = \frac{\Omega_t^C + M_t^{PC} - \Omega_t^P \left(1-\psi(1-(\bar{h}_t^P / \bar{h}_t^C))\right)^{\beta(1-\gamma)}}{w^C - w^P \left(1-\psi(1-(\bar{h}_t^P / \bar{h}_t^C))\right)^{\beta(1-\gamma)}}. \tag{11}$$

[11] To derive the threshold, note that $U_t^{PC} > U_t^P$ if the following condition holds:

$$\begin{aligned}
&(1-\beta)\log((1-\beta)(w^C h_t - \Omega_t^C - M_t^{PC})) \\
&+ \beta \log\left(\frac{\beta(1-\gamma)}{\delta-(\mu/h_t)} (1-\frac{\Omega_t^C + M_t^{PC}}{w^C h_t}) A(\frac{\gamma}{1-\gamma}(\delta h_t - \mu))^{\gamma} (\bar{h}_t^C)^{1-\gamma} w^C \right) \\
&> (1-\beta)\log((1-\beta)(w^P h_t - \Omega_t^P)) \\
&+ \beta \log\left(\frac{\beta(1-\gamma)}{\delta-(\mu/h_t)} (1-\frac{\Omega_t^P}{w^P h_t}) A(\frac{\gamma}{1-\gamma}(\delta h_t - \mu))^{\gamma} (\psi \bar{h}_t^P + (1-\psi)\bar{h}_t^C)^{1-\gamma} w^P \right).
\end{aligned}$$

Note also that in this threshold as well as in the next threshold (12) the denominator is always positive, as follows from the assumptions that $w^C > w^P$, $\bar{h}_t^C > \bar{h}_t^P$, $0 < \psi < 1$, $0 < \gamma < 1$, and $0 < \beta < 1$.

Proceeding now to the potential migrants from the core to the periphery, we follow the same steps and substitute an individual's own consumption along with the income of the offspring of that individual in the case of migration to the periphery, as shown in equations (6) and (5), respectively ($j = CP$), into the utility function (3) and compare the result to the level of utility in the case of no migration ($j = C$). This allows us to compute the threshold level of human capital for the population in the core:[12]

$$\hat{h}_t^{CP} = \frac{\Omega_t^C - (\Omega_t^P + M_t^{CP})\left(1 - \psi(1 - (\bar{h}_t^P / \bar{h}_t^C)\right)^{\beta(1-\gamma)}}{w^C - w^P\left(1 - \psi(1 - (\bar{h}_t^P / \bar{h}_t^C)\right)^{\beta(1-\gamma)}}. \tag{12}$$

The threshold level (11) divides the population in the periphery into two groups:

1. *Individuals with human capital levels lower than the threshold* $\hat{h}_t^{PC}$ who choose to remain in the periphery.

2. *Individuals with human capital levels greater than the threshold* $\hat{h}_t^{PC}$ who choose to migrate to the core.

Similarly, the threshold level (12) divides the population in the core into two groups:

1. *Individuals with human capital levels lower than the threshold* $\hat{h}_t^{CP}$ who choose to migrate to the periphery.

2. *Individuals with human capital levels greater than the threshold* $\hat{h}_t^{CP}$ who choose to remain in the core.

Equations (11) and (12) also demonstrate that the threshold level for the population in the periphery is higher than that for the population in the core; $\hat{h}_t^{PC} > \hat{h}_t^{CP}$. This implies that the migrants from the periphery to the core possess more human capital than migrants from the core to the periphery. Also notice that a decline in the congestion

---

[12] To derive the threshold, note that $U_t^{CP} > U_t^C$ if the following condition holds:

$$(1-\beta)\log((1-\beta)(w^P h_t - \Omega_t^P - M_t^{CP}))$$
$$+\beta\log\left(\frac{\beta(1-\gamma)}{\delta-(\mu/h_t)}(1-\frac{\Omega_t^P + M_t^{CP}}{w^P h_t})A(\frac{\gamma}{1-\gamma}(\delta h_t - \mu))^{\gamma}(\psi\bar{h}_t^P + (1-\psi)\bar{h}_t^C)^{1-\gamma} w^P\right)$$
$$> (1-\beta)\log((1-\beta)(w^C h_t - \Omega_t^C)) + \beta\log\left(\frac{\beta(1-\gamma)}{\delta-(\mu/h_t)}(1-\frac{\Omega_t^C}{w^C h_t})A(\frac{\gamma}{1-\gamma}(\delta h_t - \mu))^{\gamma}(\bar{h}_t^C)^{1-\gamma} w^C\right).$$

costs in the core, associated with a reduction in Ω_t^C, decreases the thresholds $\hat{h}_t^{PC}$ and $\hat{h}_t^{CP}$, thereby reducing the incentive to migrate from the core to the periphery and increasing the incentive to migrate from the periphery to the core. On the other hand, a reduction in the congestion costs in the periphery, associated with a reduction in Ω_t^P, works in the opposite direction.

2.6. Migration, human capital accumulation and public policy intervention

In this section, I show that free uncontrolled migration can increase or decrease the average level of human capital in each of the regions. Next, I consider a possibility for a public policy intervention, if migration generates a negative effect on human capital accumulation. To characterize the effect of migration on the inter-temporal evolution of human capital in the society, I examine the effect of migration in period t on the average level of human capital in the next period, in which for simplicity migration is impossible.[13]

Given the results of Section 2.5, it is intuitively clear that the out-migration increases the average level of human capital in the more advanced core ($\bar{h}_t^C > \hat{h}_t^{CP} > \bar{h}_t^{CP}$), while reducing the average human capital in the less advanced periphery ($\bar{h}_t^{PC} > \hat{h}_t^{PC} > \bar{h}_t^P$). As to the in-migration, it can either increase or decrease the average level of human capital in every region if the migrants, on average, possess more or less human capital than the local individuals. The net effect of migration on human capital is therefore uncertain. It should nonetheless be noted that if migration increases the average level of human capital in the core, while reducing the average human capital in the periphery, it still can enhance human capital accumulation in the latter, as follows from the spillover effect of human capital from the core in the learning technology in the periphery (7).

Comparing the levels of human capital in the case of free migration ($\bar{h}_{t+1}^{i,FM}$) to that in the absence of migration ($\bar{h}_{t+1}^{i,NM}$), as shown in equations (A3.1), (A3.2) and (A2) in

Appendix A, allows us to determine precisely whether migration in period t increases or decreases the average level of human capital in period $t+1$ in either region. Thus, if $\bar{h}_{t+1}^{i,FM} > \bar{h}_{t+1}^{i,NM}$, free migration increases human capital in region i. In contrast, if $\bar{h}_{t+1}^{i,NM} > \bar{h}_{t+1}^{i,FM}$, the average level of human capital in region i is higher in the absence of migration. An illustrative numerical example is provided in Appendix B.

If free uncontrolled migration leads to a reduction in human capital accumulation ($\bar{h}_{t+1}^{i,NM} > \bar{h}_{t+1}^{i,FM}$), an appropriate public policy intervention can help increase the per-capita human capital levels in both regions by reducing the attractiveness of residing in the core for less skilled individuals. Thus, for example, we can consider the following two possibilities:[14]

1. A lump-sum tax levied on every adult individual in the core by the absentee government that keeps the proceeds "outside the model".
2. A lump-sum tax imposed in the core on the in-migrants from the periphery coupled with a redistribution of the proceeds as a lump-sum subsidy to the out-migrants to the periphery.

---

[13] As follows from the property of the learning technology (7) with respect to the average level of human capital in the society, the effect of migration on human capital levels in each of the regions evolves further from one generation to the next.

[14] An analysis of bias in national taxation structures against bigger cities in the US that may induce workers to leave cities with high wage and move to cities with low wage can be found, for instance, in Albouy (2009). In a model with endogenous fertility and explicit quantity-quality trade-off, a labor-income taxation appears to be inferior to a lump-sum tax because taxation of labor income increases the relative cost of child quality, thus reducing the parental per-child investment in the education of the tax-payers' offspring and increasing fertility.

Within the framework of the present model, a labor-income tax at rate τ_t imposed on adults in the core reduces their per-child educational investment to

$$e_t^j = \frac{\gamma\delta h_t(1-\tau_t)-\mu}{1-\gamma}\ , \quad j = C, P$$

and increases the number of their children to

$$N_t^j = \frac{\beta(1-\gamma)}{\delta-(\mu/(1-\tau_t)h_t)}\begin{cases}1-(\Omega_t^i/w^i h_t), & \text{if } j = C,\\ 1-((\Omega_t^i+M_t^j)/w^i h_t, & \text{if } j = PC.\end{cases}$$

Following the same intuition, if, under Scenario 2, the subsidy to the out-migrants from the core will be assumed as proportional to their labor income in the periphery, it will shift their quantity-quality trade-off in the direction of quality, thereby strengthening this paper's major result. Arithmetically, with a subsidy at rate s_t to their labor income, their investment in the quantity and quality of their children will be

$$N_t^{CP} = \frac{\beta(1-\gamma)}{\delta-(\mu/(1+s_t)h_t)}\left(1-\frac{\Omega_t^P+M_t^{CP}}{w^P h_t}\right) \text{ and } e_t^{CP} = \frac{\gamma\delta h_t(1+s_t)-\mu}{1-\gamma}\text{ , respectively.}$$

Under Scenario 1, by increasing the cost of living in the core, taxation will increase the threshold levels, $\hat{h}_t^{PC}$ and $\hat{h}_t^{CP}$, thereby reducing migration from the periphery to the core and increasing migration from the core to the periphery. Thus, for the core, it will reduce the number of lower skilled migrants from the periphery and increase the number of relatively low-skilled out-migrants to the periphery, thereby increasing the average skill level in the region. At the same time, for the periphery, it will reduce the size of the relatively high-skilled out-migration and increase the size of the in-migration from the core. Following the same intuition as in the case of the beneficial free migration, it will improve human capital accumulation in the core, simultaneously generating a positive spillover human capital effect for the periphery, and may increase or decrease the average level of human capital in the periphery. Under Scenario 2, taxation of the in-migrants from the periphery will increase the threshold level $\hat{h}_t^{PC}$, while the subsidies provided to the out-migrants to the periphery will increase the threshold level $\hat{h}_t^{CP}$, thereby generating a similar effect on the pattern of migration. As a consequence, an appropriate public policy intervention may turn the negative effect of migration on human capital accumulation to the positive one if $\bar{h}_{t+1}^{i,NM} > \bar{h}_{t+1}^{i,FM}$, and further enhance the positive effect of migration if $\bar{h}_{t+1}^{i,FM} > \bar{h}_{t+1}^{i,NM}$. The details are provided in Appendix A. An illustrative numerical example follows in Table (1) in Appendix B.

As shown in equation (10), through its effect on the incomes of the migrants and the costs associated with congestion for all agents, migration affects the optimal choice of fertility for all individuals in the society: migrants and non-migrants alike. As a consequence, it is natural to suppose that migration will also affect reproduction rates. The present framework allows us to derive the exact condition that determines precisely whether migration increases or decreases population growth in each of the regions and the economy as a whole. Therefore, if migration leads to a reduction in population growth, a developed society that values not only human capital accumulation, but also higher reproduction rates, could find it worthwhile to increase both of them simultaneously. With such an aim, an easy way to stimulate population growth along with human capital accumulation could be to encourage some net out-migration from the densely populated core to the less populated periphery as under the previously considered Scenarios (1) and (2). If a public policy intervention increases both human capital accumulation and population growth, as a consequence, it also leads to an increase in the total amount of the productive human capital in the society as a whole. A numerical illustration is provided in Table (1) in Appendix (B). In a similar manner, a possibility of a stronger spillover effect form the core to the periphery and lower congestion costs in the periphery also can limit the net migration from the periphery to the core with a similar effect on all economic indicators, as shown in Table (1), whereas a reduction in the congestion costs in the core would work in the opposite direction.

3. Conclusion

This article analyzes the effect of population sorting on economic growth. The analysis is performed in the context of a growth model with endogenous fertility, in which public knowledge spillovers from the more advanced core into children's human capital accumulation function in the periphery are incorporated. I show how migration affects the inter-temporal evolution of human capital and derive conditions that determine precisely whether migration that takes place in one period of time increases or decreases the average level of human capital in each of the regions and the economy as a whole in the next period and further on. I discuss how public policy interventions can help increase the per-capita human capital levels, if free uncontrolled migration leads to a reduction in human capital accumulation. I also analyze how migration and public policy interventions may affect population growth.

The present analysis suggests that, in the presence of sufficiently strong core-peripheral human capital spillovers, encouraging some net out-migration of the lower skilled individuals from the densely populated core to the less densely populated periphery may simultaneously stimulate human capital accumulation and population growth. By showing how uncontrolled lower skilled migration from the periphery may inhibit human capital accumulation in the more urbanized core, thereby adversely affecting the prospects for economic growth in the whole economy, the present work also contributes to a better understanding of the phenomenon of urbanization without growth that has been observed in many presently developing countries.

Appendix A. The average level of human capital

In region i ($i = C, P$), the average human capital level in period $t+1$ is defined as shown in equation (A1):

$$\bar{h}^{i}_{t+1} \equiv \int h_{t+1} dF^{i}_{t+1}(h) = \int N^{j}_{t} h_{t+1} dF^{i}_{t}(h) \Big/ \int N^{j}_{t} dF^{i}_{t}(h)\,, \quad i = j = C, P\,. \tag{A1}$$

Distinguishing parents of each type and given the number of children and the levels of human capital investment among all types of agents as determined in Section 2.4 and with human capital production function as given in equation (7), in the absence of migration (denoted by superscript NM), the average level of human capital in region i is as shown in equation (A2):

$$\bar{h}^{i,NM}_{t+1} = A\left(\frac{\gamma}{1-\gamma}\right)^{\gamma} \frac{\int (1-\frac{\Omega^{i,NM}_{t}}{w^{i}h_{t}})(\delta h_{t}-\mu)^{\gamma-1} h_{t} dF^{i}_{t}}{\int (1-\frac{\Omega^{i,NM}_{t}}{w^{i}h_{t}})(\delta-\frac{\mu}{h_{t}})^{-1} dF^{i}_{t}} \begin{cases} (\bar{h}^{i,NM}_{t})^{1-\gamma}, & \text{if } i = C, \\ (\psi\bar{h}^{i,NM}_{t} + (1-\psi)\bar{h}^{C,NM}_{t})^{1-\gamma}, & \text{if } i = P. \end{cases} \tag{A2}$$

Correspondingly, with free migration (denoted by Superscript FM), the average levels of human capital in each of the regions are as shown in equations (A3.1) and (A3.2) for the core and the periphery, respectively:

$$\bar{h}^{C,FM}_{t+1} = \left(\frac{\gamma}{1-\gamma}\right)^{\gamma} (\bar{h}^{C}_{t})^{1-\gamma} \left[\int_{h_t > \hat{h}^{CP}_{t}} (1-\frac{\Omega^{C}_{t}}{w^{C}h_{t}})(\delta h_{t}-\mu)^{\gamma-1} h_{t} dF^{C}_{t} \right.$$

$$\left. + \int_{h_t > \hat{h}^{PC}_{t}} (1-\frac{\Omega^{C}_{t}+M^{PC}_{t}}{w^{C}h_{t}})(\delta h_{t}-\mu)^{\gamma-1} h_{t} dF^{P}_{t} \right] \Bigg/ \tag{A3.1}$$

$$\left[\int_{h_t > \hat{h}^{CP}_{t}} (1-\frac{\Omega^{C}_{t}}{w^{C}h_{t}})(\delta-(\mu/h_{t}))^{-1} dF^{C}_{t} + \int_{h_t > \hat{h}^{PC}_{t}} (1-\frac{\Omega^{C}_{t}+M^{PC}_{t}}{w^{C}h_{t}})(\delta-(\mu/h_{t}))^{-1} dF^{P}_{t} \right]$$

and

$$\bar{h}_{t+1}^{P,FM} = \left(\frac{\gamma}{1-\gamma}\right)^{\gamma} (\psi\bar{h}_t^{P} + (1-\psi)\bar{h}_t^{C})^{1-\gamma} \left[\int_{h_t < \hat{h}_t^{PC}} (1-\frac{\Omega_t^P}{w^P h_t})(\delta h_t - \mu)^{\gamma-1} h_t dF_t^P \right.$$

$$\left. + \int_{h_t < \hat{h}_t^{CP}} (1-\frac{\Omega_t^P + M_t^{CP}}{w^P h_t})(\delta h_t - \mu)^{\gamma-1} h_t dF_t^C \right] \Big/ \tag{A3.2}$$

$$\left[\int_{h_t < \hat{h}_t^{PC}} (1-\frac{\Omega_t^P}{w^P h_t})(\delta - (\mu/h_t))^{-1} dF_t^P + \int_{h_t < \hat{h}_t^{CP}} (1-\frac{\Omega_t^P + M_t^{CP}}{w^P h_t})(\delta - (\mu/h_t))^{-1} dF_t^C \right],$$

where the thresholds $\hat{h}_t^{PC}$ and $\hat{h}_t^{CP}$ are as determined in equations (11) and (12), respectively.

Proceeding now to the public policy interventions, as discussed in Section 2.6, the average levels of human capital in each of the regions can be easily computed following the same steps as in equations (A3.1) and (A3.2). Thus, with the lump-sum tax, $T_t^{C,S1}$, levied on everyone in the core by the absentee government that keeps the proceeds "outside the model" as under Scenario 1 (denoted by Superscript $S1$), the only difference is that fertility in the core becomes:

$$N_t^{j,S1} = \frac{\beta(1-\gamma)}{\delta - \frac{\mu}{h_t}} \begin{cases} 1 - \frac{\Omega_t^{C,S1} + T_t^{C,S1}}{w^C h_t}, & \text{if } j = C, \\ 1 - \frac{\Omega_t^{C,S1} + M_t^{PC} + T_t^{C,S1}}{w^C h_t}, & \text{if } j = PC, \end{cases} \tag{A4}$$

while the thresholds will be:

$$\hat{h}_t^{PC,S1} = \frac{\Omega_t^{C,S1} + T_t^{C,S1} + M_t^{PC} - \Omega_t^{P,S1}\left(1-\psi(1-(\bar{h}_t^{P,S1}/\bar{h}_t^{C,S1})\right)^{\beta(1-\gamma)}}{w^C - w^P\left(1-\psi(1-(\bar{h}_t^{P,S1}/\bar{h}_t^{C,S1})\right)^{\beta(1-\gamma)}} \tag{A5}$$

and

$$\hat{h}_t^{CP,S1} = \frac{\Omega_t^{C,S1} + T_t^{C,S1} - (\Omega_t^{P,S1} + M_t^{CP})\left(1-\psi(1-(\bar{h}_t^{P,S1}/\bar{h}_t^{C,S1})\right)^{\beta(1-\gamma)}}{w^C - w^P\left(1-\psi(1-(\bar{h}_t^{P,S1}/\bar{h}_t^{C,S1})\right)^{\beta(1-\gamma)}}. \tag{A6}$$

With the lump-sum tax, $T_t^{C,S2}$, imposed in the core on the in-migrants from the periphery coupled with a redistribution of the proceeds as a lump-sum subsidy, $S_t^{C,S2}$, to the out-migrants to the periphery as under Scenario 2 (denoted by Superscript $S2$), the required budget constraint for the redistribution is:

$$T_t^{C,S2} \int\limits_{h_t > \hat{h}_t^{PC,S2}} N_{t-1}^P dF_{t-1}^P(h^P) = S_t^{C,S2} \int\limits_{h_t < \hat{h}_t^{CP,S2}} N_{t-1}^C dF_{t-1}^C(h^C). \tag{A7}$$

The only difference in this case is that the optimal fertility choice for the inter-regional migrants is:

$$N_t^{j,S2} = \frac{\beta(1-\gamma)}{\delta - \frac{\mu}{h_t}} \begin{cases} 1 - \dfrac{\Omega_t^{C,S2} + M_t^{PC} + T_t^{C,S2}}{w^C h_t}, & \text{if } j = PC, \\ 1 - \dfrac{\Omega_t^{P,S2} + M_t^{CP} - S_t^{C,S2}}{w^P h_t}, & \text{if } j = CP, \end{cases} \tag{A8}$$

while the thresholds are:

$$\hat{h}_t^{PC,S2} = \frac{\Omega_t^{C,S2} + T_t^{C,S2} + M_t^{PC} - \Omega_t^{P,S2}\left(1 - \psi(1 - (\bar{h}_t^{P,S2} / \bar{h}_t^{C,S2}))\right)^{\beta(1-\gamma)}}{w^C - w^P\left(1 - \psi(1 - (\bar{h}_t^{P,S2} / \bar{h}_t^{C,S2}))\right)^{\beta(1-\gamma)}} \tag{A9}$$

and

$$\hat{h}_t^{CP,S2} = \frac{\Omega_t^{C,S2} - (\Omega_t^{P,S2} + M_t^{CP} - S_t^{C,S2})\left(1 - \psi(1 - (\bar{h}_t^{P,S2} / \bar{h}_t^{C,S2}))\right)^{\beta(1-\gamma)}}{w^C - w^P\left(1 - \psi(1 - (\bar{h}_t^{P,S2} / \bar{h}_t^{C,S2}))\right)^{\beta(1-\gamma)}}. \tag{A10}$$

Appendix B. Numerical illustration: Migration, human capital, population growth, and public policy interventions

To characterize the effect of migration on the evolution of human capital and population growth in either region, the following form of congestion costs is postulated:

$$\Omega_t^i = \omega^i (L_t^i)^\rho, \quad \text{where } \omega^i > 0 \text{ and } \rho > 0, \quad i = C, P. \tag{B1}$$

In period t, in the presence of the inter-regional migration, the adult population in any region consists of adult individuals born in this region with the addition of the in-migrants minus the out-migrants:

$$L_t^i \equiv \begin{cases} \int N_{t-1}^i dF_{t-1}^i(h) + \int\limits_{h_t > \hat{h}_t^{PC}} N_{t-1}^P dF_{t-1}^P(h^P) - \int\limits_{h_t < \hat{h}_t^{CP}} N_{t-1}^C dF_{t-1}^C(h^C), & \text{if } i = C, \\ \int N_{t-1}^i dF_{t-1}^i(h) + \int\limits_{h_t < \hat{h}_t^{CP}} N_{t-1}^C dF_{t-1}^C(h^C) - \int\limits_{h_t > \hat{h}_t^{PC}} N_{t-1}^P dF_{t-1}^P(h^P), & \text{if } i = P. \end{cases} \tag{B2}$$

We also assume for simplicity that, in period t, in the absence of migration, the size of the adult population in either region is normalized to unity; $L_t^{i,NM} \equiv \int N_{t-1}^i dF_{t-1}^i(h) = 1$, $i = C, P$.

We consider the following seven cases: (1) the absence of inter-regional migration, (2) free migration with a higher cost of migration from the periphery to the core, (3) free migration with a lower cost of migration from the periphery to the core, (4) public policy intervention: Scenario 1, (5) public policy intervention: Scenario 2, and (6) a stronger spillover effect from the core to the periphery, along with (7) a lower congestion costs in the periphery (denoted by NM, $FM1$, $FM2$, $S1$, $S2$, SSE, and LCP, respectively).

To provide a numerical example, suppose that the parameters in the model are as follows: $\delta = 0.15$, $\beta = 0.4$, $\psi = 0.5$, $\mu = 1$, $\gamma = 0.5$, $w^P = 1$, $w^C = 1.4$, $A = 3$, $\omega^P = 2$, $\omega^C = 18$, and $\rho = 0.2$. Also suppose that in period t, the cost of migration from the core to the periphery equals to 0.39 ($M_t^{CP} = 0.39$), whereas the cost of migration from the periphery to the core equals to 4.07 in the case of a higher migration cost ($M_t^{PC,FM1} = 4.07$) and is 1.59 in the case of a lower cost ($M_t^{PC,FM2} = 1.59$). We maintain the assumption of the lower cost of migration from the periphery to the core also for the computations of the results of the public policy interventions and the last two possibilities; $M_t^{PC,S1} = M_t^{PC,S2} = M_t^{PC,SSE} = M_t^{PC,LCP} = M_t^{PC,FM2} = 1.59$. Further suppose that, under Scenario 1, the lump-sum tax in the core equals to 3.65 ($T_t^{C,S1} = 3.65$), whereas the tax imposed in the core on the in-migrants under Scenario 2 equals to 7.62 ($T_t^{C,S2} = 7.62$).[15] Finally, for the case of the stronger spillover effect from the core to the periphery, suppose that $\psi = 0.4$ instead of $\psi = 0.5$ as in all other cases under discussion, and, for the lower congestion costs in the periphery, $\omega^P = 1.5$ instead of $\omega^P = 2$.

To complete the description of the economy, suppose that the distribution of human capital is such that in period t, in the core, among 85% of the population, human capital is distributed equally around $\overline{h}_t^{C,85\%} = 62$ with the lower bound $\overline{h}_t^{C,85\%,\min} = 46$ and the upper bound $\overline{h}_t^{C,85\%,\max} = 78$. Similarly, in the next 5% of the population in the core, human capital is distributed around $\overline{h}_t^{C,5\%} = 40$ with $\overline{h}_t^{C,5\%} \in]34, 46]$, while, for the remaining 10% of the population, $\overline{h}_t^{C,10\%} = 32$ with $\overline{h}_t^{C,10\%} \in]30, 34]$. In a similar manner, in the less advanced periphery, the distribution of human capital is such that, among 75% of the population, human capital is distributed equally around $\overline{h}_t^{P,75\%} = 28$ with the lower bound $\overline{h}_t^{P,75\%,\min} = 16$ and the upper bound $\overline{h}_t^{C,75\%,\max} = 40$. In the next 23% of the population, human capital is distributed around $\overline{h}_t^{C,23\%} = 43$ with $\overline{h}_t^{P,23\%} \in]40, 46]$, and, among 2% of the population, $\overline{h}_t^{P,2\%} = 55$ with $\overline{h}_t^{P,2\%} \in]46, 64]$.

Table (1) presents the results for the seven cases under discussion. As can be seen, with a higher cost of migration from the periphery to the core ($FM1$), free migration in period t increases the average level of human capital in either region in period $t+1$, whereas with a lower cost of migration ($FM2$), the effect of migration on human capital is opposite ($\overline{h}_{t+1}^{C,FM1} > \overline{h}_{t+1}^{C,NM} > \overline{h}_{t+1}^{C,FM2}$ and $\overline{h}_{t+1}^{P,FM1} > \overline{h}_{t+1}^{P,NM} > \overline{h}_{t+1}^{P,FM2}$). If free migration is human capital diluting as in Case 3 ($FM2$), public policy interventions as under Scenarios (1) and (2) can help improve human capital accumulation not only relative to the case when migration is absent (NM), but also relative to the case of human capital enhancing migration ($FM1$) ($\overline{h}_{t+1}^{C,S2} > \overline{h}_{t+1}^{C,S1} > \overline{h}_{t+1}^{C,FM1} > \overline{h}_{t+1}^{C,NM} > \overline{h}_{t+1}^{C,FM2}$; $\overline{h}_{t+1}^{P,S1} > \overline{h}_{t+1}^{P,S2} > \overline{h}_{t+1}^{P,FM1} > \overline{h}_{t+1}^{P,NM} > \overline{h}_{t+1}^{P,FM2}$). Similarly, if free migration reduces population growth and human capital accumulation in the economy as a whole as under $FM2$, public policy interventions can help overturn the trend ($L_{t+1}^{T,S2} > L_{t+1}^{T,S1} > L_{t+1}^{T,NM} > L_{t+1}^{T,FM2}$; $H_{t+1}^{T,S2} > H_{t+1}^{T,S1} > H_{t+1}^{T,NM} > H_{t+1}^{T,FM2}$). Likewise, stronger spillover effects and lower congestion costs in the periphery also limit the net migration from the periphery to the core, thereby improving human capital accumulation and all other economic indicators relative to the baseline $FM2$ scenario.

Table 1. Numerical example: Seven cases

---

[15] Under Scenario 2, with the lump-sum in the core on the in-migrants $T_t^{C,S2} = 3.65$, the resulting subsidy

	NM	$FM1$ $M_t^{PC,FM1}=4.07$	$FM2$ $M_t^{PC,FM2}=1.59$	$S1$ $T_t^{C,S1}=3.65$	$S2$ $T_t^{C,S2}=7.62$	SSE $\psi=0.4$	LCP $\omega^P=1.5$
L_t^C	1	0.92	1.14	0.89	0.91	1.11	1.11
L_t^P	1	1.08	0.86	1.11	1.09	0.89	0.89
$\bar{h}_t^C$	57.9	60.7	57.3	61.5	60.9	57.8	57.8
$\bar{h}_t^P$	32	31.6	28.5	31.7	31.8	29.0	29.0
$\hat{h}_t^{PC}$		46	40	46	55	40.8	40.8
$\hat{h}_t^{CP}$		34	35.7	41.7	35.4	36.5	36.5
Ω_t^C	18	17.70	18.49	17.58	17.64	18.38	18.38
Ω_t^P	2	2.03	1.94	2.04	2.03	1.95	1.47
$\bar{h}_{t+1}^C$	63.2	66.5	62.6	67.5	69.3	63.2	63.2
$\bar{h}_{t+1}^P$	38.7	39.0	35.5	39.3	39.2	37.2	36.1
L_{t+1}^C	1.16	1.09	1.30	1.00	1.03	1.28	1.28
L_{t+1}^P	1.58	1.72	1.39	1.77	1.75	1.44	1.47
L_{t+1}^T	2.74	2.81	2.69	2.77	2.78	2.72	2.75
H_{t+1}^T	134.5	139.3	131.0	136.8	139.9	134.5	134

Notes: $L_{t+1}^T \equiv L_{t+1}^C + L_{t+1}^P$ refers to the total size of the adult population, whereas $H_{t+1}^T \equiv H_{t+1}^C + H_{t+1}^P$ is the total amount of the productive human capital in the economy as a whole in period $t+1$.

References

Abdel-Rahman, H.M., Wang, P. (1997) Social welfare and income inequality in a system of cities. *Journal of Urban Economics* 41, 462–483.

Albouy, D. (2009) The unequal geographic burden of federal taxation. *Journal of Political Economy* 117, 635–667.

Albouy, D., Behrens, K., Robert-Nicoud, F., Seegert, N. (2019) The optimal distribution of population across cities. *Journal of Urban Economics* 110, 102–113.

Amin, A., Cohendet, P. (2004) *Review of Architectures of Knowledge: Firms, Capabilities and Communities*. Oxford: Oxford University Press.

Au, C.-C., Henderson, J.V. (2006) Are Chines cities too small? *Review of Economic Studies* 73, 549–576.

---

to the out-migrants is $S_t^{C,S2} = 0.72$.

Autanat-Bernard, C., Lesage, J. (2011) Quantifying knowledge spillovers using spatial econometric tools. *Journal of Regional Science* 51, 471–496.

Autanat-Bernard, C., Fadairo, M., Massard, N. (2013) Knowledge diffusion and innovation policies within the European regions: Challenges based on recent empirical evidence. *Research Policy* 42, 196–210.

Azarnert, L.V. (2008) Foreign aid, fertility and human capital accumulation. *Economica* 75, 766–781.

Azarnert, L.V. (2010a) Free education, fertility and human capital accumulation. *Journal of Population Economics* 23, 449–468.

Azarnert, L.V. (2010b) Après nous le déluge: Fertility and the intensity of struggle against immigration. *Journal of Population Economics* 23, 1339–1349.

Azarnert, L.V. (2016) Transportation costs and the great divergence. *Macroeconomic Dynamics* 20, 214–228.

Azarnert LV (2012) Male versus female guest-worker migration: Does it matter for fertility in the source country?' *Research in Economics* 66, 1–6.

Azarnert, L.V. (2018) Refugee resettlement, redistribution and growth. *European Journal of Political Economy* 54, 89–98.

Azarnert, L.V. (2019) Migration, congestion and growth. *Macroeconomic Dynamics* 23, 3035–3064.

Azarnert, L.V. (2020) Health capital provision and human capital accumulation. *Oxford Economic Papers* 72, 633–65.

Barro, R.J., Sala-i-Martin, X. (1992) Public finance in models of economic growth. *Review of Economic Studies* 59, 645–661.

Bayer, C., Juessen, F. (2012) On the dynamics of interstate migration: Migration costs and self-selection. *Review of Economic Dynamics* 15, 377–401.

Behrens, K., Duranton, G., Robert-Nicoud, F. (2014) Productive cities: Sorting, selection and agglomeration. *Journal of Political Economy* 122, 507–553.

Behrens, K., Robert-Nicoud, F. (2014) Survival of the fittest in cities: Urbanization and inequality. *Economic Journal* 124, 1371–1400.

Bruckner, J.K. (1981) Congested public goods: The case of fire protection. *Journal of Public Economics* 15, 45–58.

Cai, F. (2006) *Floating Population: Urbanization with Chinese Characteristics*. Chinese Academy of Social Sciences, Beijing, China.

Castells-Quintana, D. (2017) Malthus living in a slum: Urban concentration, infrastructure and economic growth. *Journal of Urban Economics* 98, 158–173.

Chen, Y., Henderson, J.V., Cai, W. (2017) Political favoritism in China's capital markets and its effect on city size. *Journal of Urban Economics* 98, 69–87.

Chen, Z., Guan, J. (2016) The core-peripheral structure of international knowledge flows: Evidence from patent citation data. *R&D Management* 46, 62–79.

Coe, D.T., Helpman, E., Hoffmaister, A.W. (1997) North-South R&D spillovers. *Economic Journal* 107, 134–149.

Coe, D.T., Helpman, E., Hoffmaister, A.W. (2009) International R&D spillovers and institutions. *European Economic Review* 53, 723–741.

Cohen, W., Levinthal, D. (1989) Innovations and learning: The two faces of R&D. *Economic Journal* 99, 569–596.

Combes, P.-P., Duranton, G., Gobillon, L. (2019) The costs of agglomeration: House and land prices in French cities. *Review of Economic Studies* 86, 1556–1589.

Cullen, J.B., Levitt, S.D. (1999) Crime, urban flight, and the consequences for cities. *Review of Economics and Statistics* 81, 159–169.

Dahan, M., Tsiddon, D. (1998) Demographic transition, income distribution and economic growth. *Journal of Economic Growth* 3, 29–52.

Dahmann, N., Wolch, J., Joassart-Marcelli, P., Reynolds, K., Jerrett, M. (2010) The active city? Disparities in the provision of urban recreation resources. *Health & Place* 16, 431–445.

de la Croix, D., Doepke, M. (2003) Inequality and growth: Why differential fertility matters. *American Economic Review* 93, 1091–1113.

de la Croix, D., Doepke, M. (2004) Public versus private education when differential fertility matters. *Journal of Development Economics* 73, 607–629

Delogu, M., Docquier, F., Machado, J. (2018) Globalizing labor and the world economy: The role of human capital. *Journal of Economic Growth* 23, 223–258.

Derlet, R.W., Richards, J.R. (2000) Overcrowding in the nation's emergency departments: Complex causes and disturbing. *Annals of Emergency Medicine* 35, 63–67.

Desmet, K., Rossi-Hansberg, E. (2013) Urban accounting and Welfare. *American Economic Review* 103, 2296–2327.

Desmet, K., Rossi-Hansberg, E. (2015) On the spatial economic impact of global warming. *Journal of Urban Economics* 88, 16–37.

Davis, D.R., Dingel, J.I. (2019) A spatial knowledge economy. *American Economic Review* 109, 153–170.

Docquier, F., Machado, M., Sekkat, K. (2015) Efficiency gains from liberalizing labor mobility. *Scandinavian Journal of Economics* 117, 303–346.

Duranton, G., Puga, D. (2020) The economics of urban density. *Journal of Economic Perspectives* 34, 3–26.

Duranton, G., Puga, D. (2004) Micro-foundation of urban agglomeration economies. In Henderson, J.V., Thisse, J.-F. (eds.) *Handbook of Urban and Regional Economics*, North Holland, Amsterdam: Elsevier, Vol. 4, pp. 2065–2118.

Eaton, J., Eckstein, Z. (1997) Cities and Growth: Theory and evidence from France and Japan. *Regional Science and Urban Economics* 27, 443–474.

Eeckhout, J., Pinheiro, R., Schmidheiny, K. (2014) Spatial sorting. *Journal of Political Economy* 122, 554–620.

Fajgelbaum, P.D., Gaubert, C. (2020) Optimal spatial policies, geography, and sorting. *Quarterly Journal of Economics* 135, 959–136.

Feler, L., Henderson, J.V. (2011) Exclusionary policies in urban development: Under-servicing migrant households in Brazilian cities. *Journal of Urban Economics* 69, 253–272.

Fujita, M. (1989) *Urban Economic Theory: Land use and City Size*. Cambridge: Cambridge University Press.

Galor, O. (2011) *Unified Growth Theory*. Princeton, NJ: Princeton University Press.

Galor, O. (2012) The demographic transition: Causes and consequences. *Cleometrica* 6, 1–28.

Galor, O., Moav, O. (2000) Ability biased technological transition, wage inequality and economic growth. *Quarterly Journal of Economics* 115, 469–498.

Galor, O., Moav, O. (2002) Natural selection and the origin of economic growth. *Quarterly Journal of Economics* 117, 1133–1191.

Galor, O., Mountford, A. (2008) Trading population for productivity: Theory and evidence. *Review of Economic Studies* 75, 1143–1179.

Galor, O., Tsiddon, D. (1997) The distribution of human capital and economic growth. *Journal of Economic Growth* 2, 93–124.

Gibbons, S., (2004) The cost of urban property crime. *Economic Journal* 114, F441–F463.

Glaeser, E.L. (2014) A world of cities: The causes and consequences of urbanization in poorer countries. *Journal of the European Economic Association* 12, 1154–1199.

Glaeser, E.L., Sacerdote, B. (1999) Why is there more crime in cities? *Journal of Political Economy* 107, S225–S258.

Glaeser, E.L., Gyourko, J., Saks, R. (2005) Why is Manhattan so expensive? Regulations and the rise in housing prices. *Journal of Law and Economics* 48, 331–369.

Gomes-Casseres, B., Hagendoorn, J., Jaffe, A.B. (2006) Do alliances promote knowledge flows? *Journal of Financial Economics* 80, 5–33.

Gyourko, J., Mayer, C., Sinai, T. (2013) Superstar cities. *American Economic Journal: Economic Policy* 5, 167–199.

Helpman E., Hillman A.L. (1977) Two remarks on optimal club size. *Economica* 44, 293–296.

Henderson, J.V. (1974) The size and type of cities. *American Economic Review* 64, 640–656.

Henderson, J.V. (1988) *Urban Development: Theory, Fact and Illusion*. Oxford: Oxford University Press.

Henderson, J.V. (2002) Urban primacy, external costs, and quality of life. *Resource and Energy Economics* 24, 95–106.

Henderson, J.V. (2003) The urbanization process and economic growth: The so-what question. *Journal of Economics Growth* 8, 47–71.

Henderson, J.V., Venables, A.J. (2009) The dynamics of city formation. *Review of Economic Dynamics* 12, 233–254.

Henderson, J.V., Wang, H.G. (2005) Aspects of the rural-urban transformation of countries. *Journal of Economic Geography* 5, 23–42.

Hilber, C.A., Robert-Nicoud, F. (2005) On the origins of land use regulations: Theory and evidence from US metro areas. *Journal of Urban Economics* 75, 29–43.

Hiller, V., Toure N. (2021) Endogenous gender power: The two facets of empowerment. *Journal of Development Economics* 149, 102596.

Hillman, A.L., Swan, P.L. (1983) Participation rules for Pareto-optimal clubs. *Journal of Public Economics* 20, 55–76.

Hu, A.G.Z., Jaffe, A.B. (2003) Patent citations and international knowledge flows: The case of Korea and Taiwan. *International Journal of Industrial Organization* 21, 849–880.

Jaffe, A.B., Trajtenberg, M., Henderson, R. (1993) Geographic localization of knowledge spillovers: evidenced by patent citations. *Quarterly Journal of Economics* 108, 577–598.

Jaffe, A.B., Trajtenberg, M. (1999) International knowledge flows: Evidence from patent citations. *Economics of Innovation and New Technology* 8, 105–136.

Jedwab, R., Christiaensen, L., Gindelsky, M. (2017) Demography, urbanization and development: Rural push, urban pull and … urban push? *Journal of Urban Economics* 98, 6–16.

Jedwab, R., Vollrath, D. (2019) The urban mortality transition and poor-country urbanization. *American Economic Journal: Macroeconomics* 11, 223–275.

Jepsen, C., Rivkin, S. (2009) Class size reduction and student achievement. *Journal of Human Resources* 44, 223–250.

Keller, W. (2002) Geographic localization of international technology diffusion. *American Economic Review* 92, 120–142.

Keller, W. (2004) International technology diffusion. *Journal of Economic literature* 42, 752–782.

Kanemoto, Y. (1980) *Theories of Urban Externalities*. North–Holland: Amsterdam.

Kulu, H. (2008) Fertility and spatial mobility in the life course: Evidence from Austria. *Environment and Planning A* 40, 632–652.

Lindgren, U. (2003) Who is the counter-urban mover? Evidence from the Swedish urban system. *International Journal of Population Geography* 9, 399–418.

Liu, C.H., Rosenthal, S.S., Strange, W.C. (2018) The vertical city: Rent gradients, spatial structure, and agglomeration economies. *Journal of Urban Economics* 106, 101–122.

Liu, Y., Lan, B., Shirai, J., Austin, E., Yang, C., Seto, E. (2019) Exposure to air pollution and noise from multi-modal commuting in a Chinese city. *International Journal of Environmental Research and Public Health* 16, 2539.

Malmberg, B. (2012) Fertility cycles, age structure and housing demand. *Scottish Journal of Political Economy* 59, 467–482.

McCann, P., Shefer, D. (2004) Location, agglomeration and infrastructure. *Papers in Regional Science* 83, 177–196.

McGarvie, M. (2005) The determinants of international knowledge diffusion as measured by patent citations. *Economic Letters* 87, 121–126.

Moav, O. (2005) Cheap children and the persistence of poverty. *Economic Journal* 115, 88–110.

Mori, T., Turrini, A. (2005) Skill, agglomeration and segmentation. *European Economic Review* 49, 201–225.

Mountford, A. (1997) Can a brain drain be good for growth in the source economy? *Journal of Development Economics* 53, 287–303.

Mountford, A., Rapoport, H. (2011) The brain drain and the world distribution of income. *Journal of Development Economics* 95, 4–17.

Murphy, K.M., Simon, C.J., Tamura, R. (2008) Fertility decline, baby boom, and economic growth. *Journal of Human Capital* 2, 262–302.

Peri, G. (2005) Determinants of knowledge flows across the European regions. *Review of Economic Studies* 87, 308–322.

Richardson, H.W. (1987) The costs of urbanization: A four country comparison. *Economic Development and Cultural Change* 33, 561–580.

Richardson, D.B., Mountain, D. (2009) Myths versus facts in emergency department overcrowding and hospital access block. *Medical Journal of Australia* 190, 369–374.

Sato, Y. (2007) Economic geography, fertility and migration. *Journal of Urban Economics* 61, 372–387.

Sato, Y., Yamamoto, K. (2005) Population concentration, urbanization, and demographic transition. *Journal of Urban Economics* 58, 45–61.

Schull, M.J., Szalai, J.-P., Schwartz, B., Redelmeier, D.A. (2001) Emergency department overcrowding following systematic hospital restructuring: Trends at twenty hospital over ten years. *American Emergency Medicine* 8, 1037–1043.

Simon, C.J., Tamura, R. (2009) Do higher rents discourage fertility? Evidence from U.S. cites, 1940–2000. *Regional Science and Urban Economics* 39, 33–42.

Singh, J. (2005) Collaboration networks as determinants of knowledge diffusion patterns. *Management Science* 51, 756–770.

Sprivulis, P.C., Da Silva, J.-A., Jacobs, I.G., Frazer, A.R.L., Jelinek, G.A. (2006) The association between hospital overcrowding and mortality among patients admitted via Western Australian emergency departments. *Medical Journal of Australia* 184, 208–212.

Tabuchi, T. (1998) Urban agglomeration and dispersion: A synthesis of Alonso and Krugman. *Journal of Urban Economics* 44, 333–351.

Tamura, R. (1991) Income convergence in an endogenous growth model. *Journal of Political Economy* 99, 522–540.

Tamura, R. (1996) From decay to growth: A demographic transition to economic growth. *Journal of Economic Dynamics and Control* 20, 1237–1261.

Tamura, R. (2006) Human capital and economic development. *Journal of Development Economics* 79, 26–72

Tamura, R., Cuberes, D. (2020) Equilibrium and *A*-efficient fertility with increasing returns to population and endogenous mortality. *Journal of Demographic Economics* 86, 157–182.

Trzeciak, S., Rivers, E.P. (2003) Emergency department overcrowding in the United States: An emerging threat to patient safety and public health. *Emergency Medicine Journal* 20, 402–405.

Venables, A.J. (2005) Spatial disparities in developing countries: Cities, regions, and international trade. *Journal of Economic Geography* 5, 3–21.

Viaene, J.M., Zilcha, I. (2009) Human capital and inequality dynamics. *Economica* 76, 760–778.

Vidal, S., Huinink, J., Feldman, M. (2017) Fertility intentions and residential relocations. *Demography* 54, 1305–1330.