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Labor Markets and Sustainability: Short-Run Dynamics and Long-Run Equilibrium

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Abstract: Many of the world's economies experienced rapid structural changes due to globalization and other forces over the past 50 years. During this period, developing countries were the recipients of massive foreign direct investment, and their industrialization was accompanied by urbanization, city gigantism, and related environmental issues, such as pollution. Over time, investments in the education of the urban poor allowed their move from the industrial sector to the service sector. This growth of the service sector came at the expense of the industrial sector, which implied structural changes in cities and massive cleaning efforts. The objective of this study is to model these transitions in a simple dynamic framework. The economic model indicates that in the short run, urban growth is negatively impacted by environmental degradation and agglomeration costs, while service sector growth is negatively impacted by environmental cleaning costs. In the long run, optimal city and service sizes are both decreasing functions of environmental degradation and agglomeration and cleaning costs. Thus, sustainability ultimately determines the optimal city size.

Keywords: Harris–Todaro model; rural–urban migration; labor market dynamics; sustainability; urbanization; megacities; environmental degradation; environmental cleaning costs

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1. Introduction

As a result of globalization and other forces, many of the world's economies experienced rapid structural changes over the past 50 years. During this period, developing countries that were once characterized as agricultural economies were the recipients of massive foreign direct investment [1,2]. (The theoretical approaches in these cited studies focus on the role played by the creation and nurturing of pro-market institutions in attracting foreign direct investment. Earlier empirical investigations support the importance of similar institution-building reforms related to privatization in generating inward foreign direct investment throughout Latin America [3]. Other work finds that the deregulation in the former socialist countries of Eastern Europe led to greater foreign direct investment within their borders [4]). The pace of industrialization in these countries increased, and they were enriched through the production of goods for export. Industrialization was accompanied by urbanization, city gigantism, and related environmental issues, such as pollution. Over time, investments in the education of the urban poor allowed their move from the industrial sector to the service sector. This growth of the service sector came at the expense of the industrial sector, which implied structural changes in cities and massive cleaning efforts. The objective of this study is to model these transitions in a simple dynamic framework, emphasizing the relationship between labor markets and the environment.

Our research hypothesis is that the mass migration from rural areas to industrial centers (due to industrialization), combined with the growth of the services sector that reduced the relative size and importance of the industrial sector (due to investments in education), has two predictable environmental results. First, the transition associated with the rural–urban migration due to industrialization predictably has a negative impact on the environment. Second, the transition from an industrial economy toward a service economy predictably has a positive cleaning effect on the environment.

The objective of this paper is to analyze these theoretical impacts on the environment. In doing so, we focus on both the short-run dynamics of these transitions and the long-run steady-state equilibrium. The economic model indicates that in the short run urban growth is negatively impacted by environmental degradation and agglomeration costs, while service sector growth is negatively impacted by environmental cleaning costs. In the long run, optimal city and service sizes are both decreasing functions of environmental degradation, and agglomeration and cleaning costs. Thus, sustainability ultimately determines the optimal city size.

Before turning to the aforementioned stylized dynamic model, we first provide a brief review of the academic literature published since the turn of the century that focuses on extensions of the foundational Harris–Todaro model [5]. Included in this branch of economics literature are studies on increasing urbanization, the development of megacities, and various country studies. Next, Section 3 presents the short-run dynamics and the long-run equilibrium of the model. Section 4 discusses directions for future research while concluding remarks appear in Section 5.

2. Prior Literature: A Brief Review

Our review of prior literature focuses mainly on issues related to key aspects of our stylized dynamic model. The first subsection below discusses relevant theoretical extensions of the Harris–Todaro framework that have appeared in the academic literature during the past 20 years. The following subsection examines recent academic work on the development of and issues surrounding megacities. Lastly, this section of the study concludes with a description of some of the related country studies that have been published since the turn of the century.

2.1. Theoretical Extensions of the Harris–Todaro Framework

An important early study by Brueckner and Zenou adds a land market to the original Harris–Todaro framework [6]. It points out that the equilibrating force in the Harris–Todaro approach that inhibits rural–urban migration is a decrease in the probability of formal employment, which is preceded by growth of the informal sector. This particular extension of the Harris–Todaro framework illustrates that the rise in urban land rent provides an additional factor that reduces migration [6]. The most striking implication is that formal sector growth may not result in greater migration from rural areas, given that, because of higher land rent, such growth may reduce a migrant's expected utility even in the face of a higher probability of securing a formal job [6]. A follow-up study by Brueckner and Kim assumes that city residents smooth their incomes as they transition between formal and informal employment [7]. This assumption follows Harris–Todaro by allowing migration decisions to be a function of the expected wage while at the same time including a land market [7].

Next, an interesting extension by Moreno-Monroy and Posada follows a spatial search process wherein formal workers face a daily commute to and from the Central Business District (CBD) in order to work in formal firms [8]. At the same time, informal workers choose when to travel to work, knowing that they either can work at home and save on travel costs or earn a higher income in the CBD while also facing higher commuting costs [8]. The study shows that the difference in urban costs between types of employment is a mechanism through which enhancements in accessibility lead to lower rates of informal employment [8]. A more recent study by Caliendo, Cobb-Clark, Hennecke, and Uhlendorff considers migration across domestic labor markets to be the outcome of an employment search process in which applicants form subjective beliefs about the endogenous return to search effort [9]. The model asserts that applicants with an internal locus of control will search across more expansive geography and migrate more frequently [9].

Wang and Fu developed a model calibrated to explore the effects of China's labor market reforms on labor migration that focuses on the importance of selection effects to various labor market outcomes [10]. They find that although elimination of legal impediments to migration and reductions in migration costs are beneficial, rural–urban migration results in a rural brain drain and inhibits agricultural production while also increasing the prices of agricultural products [10] (Relatedly, Faria and Mollick study forced migration, led by urban–rural tax differentials, that results in a very fast migration adjustment, which was a characteristic of Stalin's and other communist regimes' policies [11]). Additionally, while migration reduces the urban–rural labor income gap, it actually increases urban–rural income inequality when returns to capital are considered. Gilbert and Oladi explore, from the perspective of a small developing economy, the impact of a labor-eliminating technical change which, in contrast to a labor-augmenting technical change, does not necessarily reduce costs and is not necessarily adopted [12]. According to Gilbert and Oladi, a manufacturing wage set artificially higher than its market-clearing level, as in the Harris–Todaro framework, increases the incentive for automation [12]. Lastly, their extension establishes the conditions under which firms will opt for a labor-eliminating technology and describes the resulting changes in equilibrium outcomes. For example, automation may lead to an increase in both the rate and level of unemployment [12].

Finally, a new study by Yu and Chow considers an economy with a dual production structure, such as China, in order to explore the income distribution and welfare effects of nurturing and growing the urban informal sector [13]. In the short run, a land-rent policy for nurturing the informal sector addresses the wage inequality between skilled and unskilled labor, while a land-supply policy increases the wage gap. In the long run, the land-rent policy can increase the skilled–unskilled wage gap given the free entry of firms into the urban industrial sector, while the land supply narrows the gap with a firm exit from the urban industrial sector [13].

2.2. Megacities

An early study by Molina and Molina indicates that the expansion of urban centers is creating an increase in megacities, which are defined as metropolitan areas with populations exceeding 10 million [14]. This process is exerting substantial costs to the natural environment, with impacts at nearly all levels. For example, air pollution has become endemic in megacities, with sulfur compounds generated largely by burning coal constituting the early source of this problem in both the developed and developing world [14]. Currently, photochemical smog from traffic and industrial activities, power generation, and solvents have become the primary source of concern for air quality in the developed world [14]. Air pollution has a negative effect on public health, causes urban and regional haze, and possibly contributes significantly to climate change. However, with proper planning, megacities can efficiently address their air quality issues by applying new emission control technologies and making greater use of mass transit systems [14].

Next, a study by Varis, Biswas, Tortajada, and Lundqvist asserts that developing efficient and equitable management approaches to water, wastewater, and stormwater in megacities is becoming an increasingly vexing task, particularly given the prevalence of aging water infrastructure, large public debts, and inadequate governance, institutional frameworks and legal and regulatory regimes [15]. Subsequent work by Parrish and Zhu reports that the number of megacities grew from only three in 1975 to 19 in 2007 and is projected to increase to 27 in 2025 [16]. Although megacities sustain growing economies, they are also substantial sources of air pollutants. As such, although the growth of megacities is associated with the health impacts of pollution, they also provide a platform to address climate change if beneficial air quality policies are developed to address climate problems [16].

Lastly, Parrish, Singh, Molina, and Madronich review air quality enhancements in three North American megacities [17]. They find that although measurable progress has been made in dealing with concomitant air pollution, the impact of pollutant emissions from megacities is experienced beyond their boundaries, and typically there are no policy mechanisms in place to address pollution transport of this kind. In this regard, Silva and Caplan discuss two policy instruments (i.e., pollution abatement and tax) to deal with it, and show that the best outcomes occur when the central government is the policy leader [18]. Finally, a more recent review of air quality in megacities by Baklanov, Molina, and Gauss focuses on the complex relationships between climate, air quality, and megacities and discusses how services enhance cities' efforts to address hazards such as storm surge, flooding, heatwaves, and air pollution episodes, especially in changing climates [19].

2.3. Country Studies

Agesa uses data from Kenya in order to provide an appropriate measure of the forces propelling rural–urban migration in developing countries [20]. The study decomposes the urban–rural wage gap to separately account for differences in explained characteristics of rural non-migrant workers and migrant urban workers, and that segment of the wage gap that is due to returns to observed attributes. The results suggest that observable attributes both constitute the largest segment of the wage gap and provide a more accurate measure of the propensity for rural–urban migration. Next, Ghatak, Mulhern, and Watson extend the Harris–Todaro model of migration by considering the importance of human capital, housing, and the availability of publicly provided amenities in migration in different areas of Poland [21]. Their results show that GDP per capita, unemployment, and distance have a substantial impact on regional migration in Poland, while human capital is also important in explaining the provision of roads. On the other hand, the paucity of housing in Poland plays a significant part in explaining the low levels of internal migration [21].

Using experimental evidence eliciting individual risk and time preferences along with household survey data from coastal communities in Ghana and Indonesia, Goldbach and Schlüter find that out-migrants from both regions are significantly less risk-averse and have a lower time preference than non-migrants [22]. Overall, the results suggest that individual preferences play a similarly important role as employment status, education, or networks in explaining individual migration. Next, Saracoğlu and Roe test a dynamic model of an economy with rural–urban migration in order to study each economic region's output and factor allocation, as well as any inter-regional differences that result from migration [23]. Tests using data from Turkey suggest that migration both slows and dampens the urban manufacturing-to-services labor migration, despite the increase in demand for urban services. They also suggest that rural–urban migration relates positively to growth while within-region reallocation of labor has negative effects [23].

Finally, a new study by Busso, Chauvin, and Herrera examines data from 449 cities and rural regions in Brazil to assess the usefulness of the Harris–Todaro model at high levels of urbanization—a prominent aspect of many developing countries [24]. Empirical models that integrate labor informality and housing markets outperform traditional models, and Harris–Todaro equilibrium relationships are relatively stronger among workers whose education attainment falls short of high school. The relationships are found most often among relatively large cities and when the proximate rural areas are closer to the urban environment and consist of a relatively large population of young adults, who exhibit a greater propensity to migrate [24].

3. A Stylized Dynamic Model

3.1. Short-Run Dynamics

In line with the Harris–Todaro model, we assume that rural–urban migration, M, is an increasing function of the differential between the industry wage, W, and that in agriculture, w,

$$\dot{M} = M(W - w),\ M' > 0 \tag{1}$$

We assume $W > w$ in order to have rural–urban migration, where $M > 0$. Next, the city's population growth, $\dot{U} \equiv dU/dt$, is an increasing function of migration, and a decreasing function of its own size, U, due to higher land prices, environmental degradation, and transportation and agglomeration costs. All of these are captured by the parameter b, yielding,

$$\dot{U} = aM(W - w) - bU \tag{2}$$

Urban growth is affected positively by the growth rate of migration, a, and by the industry-rural wage differential, $(W - w)$. Urban growth is negatively impacted by environmental degradation and agglomeration costs, given by b, and by the city size, assuming it passed a critical threshold size, $\overline{U} < U$,

$$\frac{d\dot{U}}{da} = M(W - w) > 0;\ \frac{d\dot{U}}{d(W - w)} = aM' > 0; \frac{d\dot{U}}{db} = -U < 0;\ \frac{d\dot{U}}{dU} = -b \tag{3}$$

In cities, the supply of basic education is cheaper. Mass education, represented by the number of educated individuals, E, becomes more common. This allows for the spread of new technologies and skills. The service sector is the greater beneficiary of mass education. Mass education is driven by wages, W_E, that are higher than those paid in the industrial sector, W,

$$\dot{E} = E(W_E - W); E' > 0 \tag{4}$$

Thus far, the dynamic analysis of M, U, and E has focused only on wage differentials, ignoring any environmental issues that may influence their dynamics. Another shortcoming is that it does not anticipate the relocation of industry and services to rural areas. However, when one considers the dynamics of the service sector, S, the environment plays an important role. Over time, service sector growth, $\dot{S}$, is a function of the increasing number of educated individuals, E, and is limited by an environmental issue, namely, the cleaning costs associated with the transformation of the city's landscape from an industrial site in order to accommodate a brand new service sector, captured by the parameter δ,

$$\dot{S} = \alpha E(W_E - W) - \delta \frac{S}{U} \tag{5}$$

Service sector growth is affected positively by the growth rate of education, α, the services-industry wage differential, $(W_E - W)$, and by the city's size, U. Service sector growth is negatively impacted by cleaning costs, δ, and by the service sector size with respect to the city size, S/U,

$$\frac{d\dot{S}}{d\alpha} = E(W_E - W) > 0;\ \frac{d\dot{S}}{d(W_E - W)} = \alpha E' > 0; \frac{d\dot{S}}{d\delta} = -\frac{S}{U} < 0;\ \frac{d\dot{S}}{dS} = -\frac{\delta}{U}; \frac{d\dot{S}}{dU} = \frac{\delta S}{U^2} > 0 \tag{6}$$

The dynamic model is given by the differential Equations in (2) and (5). They describe the short-run behavior of the model. In the next subsection, we examine the long-run equilibrium of the model.

3.2. Long-Run Equilibrium

The long-run equilibrium is the steady-state equilibrium, defined as $\dot{S} = \dot{U} = 0$. It is denoted by an asterisk,

$$\dot{U} = aM(W - w) - bU,\ then\ \dot{U} = 0 \Rightarrow U^* = \frac{a}{b}M(W - w) \tag{7}$$

and

$$\dot{S} = \alpha E(W_E - W) - \delta \frac{S}{U},\ then\ \dot{S} = 0 \Rightarrow S^* = \frac{\alpha}{\delta}U^* E(W_E - W)$$

Using (7) yields,

$$S^* = \frac{\alpha}{\delta}\frac{a}{b}[M(W - w)][E(W_E - W)] \tag{8}$$

According to (7), the long-run optimal size of the city, U^*, is an increasing function of migration, which is an increasing function of the industry-rural wage differential and migration growth rate, while it is a decreasing function of environmental degradation and agglomeration costs,

$$\frac{dU^*}{d(W-w)} = \frac{a}{b}M' > 0; \frac{dU^*}{da} = \frac{1}{b}M(W-w); \frac{dU^*}{db} = -\frac{a}{b^2}M(W-w) < 0 \quad (9)$$

According to (8), the long-run optimal size of the service sector, S^*, is an increasing function of migration, which is an increasing function of the industry-rural wage differential, migration growth rate, education—which depends on the service-industry wage differential—and the education growth rate. Next, S^* is a decreasing function of environmental degradation, agglomeration costs, and cleaning costs,

$$\frac{dS^*}{d(W-w)} = \frac{\alpha}{\delta}\frac{a}{b}M'[E(W_E-W)] > 0; \frac{dS^*}{d(W_E-W)} = \frac{\alpha}{\delta}\frac{a}{b}E'[M(W-w)] > 0;$$

$$\frac{dS^*}{da} = \frac{\alpha}{\delta}\frac{1}{b}M(W-w)[E(W_E-W)] > 0; \frac{dS^*}{d\alpha} = \frac{1}{\delta}\frac{a}{b}[M(W-w)][E(W_E-W)] > 0;$$

$$\frac{dS^*}{db} = -\frac{\alpha}{\delta}\frac{a}{b^2}[M(W-w)][E(W_E-W)] < 0; \frac{dS^*}{d\delta} = -\frac{a}{b}\frac{\alpha}{\delta^2}[M(W-w)][E(W_E-W)] < 0 \quad (10)$$

In order to analyze the stability of the long-run equilibrium, (U^*, S^*), as given by (7) and (8), we first derive the Jacobian below,

$$J = \begin{bmatrix} \frac{\partial \dot{U}}{\partial U} & \frac{\partial \dot{U}}{\partial S} \\ \frac{\partial \dot{S}}{\partial U} & \frac{\partial \dot{S}}{\partial S} \end{bmatrix}_{(U^*,S^*)} = \begin{bmatrix} -b & 0 \\ \frac{\delta S^*}{U^{*2}} & \frac{-\delta}{U^*} \end{bmatrix} \quad (11)$$

Next, from the Jacobian in (11), we calculate the determinant $\mid J \mid$ and the trace, tr$J$, of the Jacobian,

$$\mid J \mid = \frac{\delta b}{U} = \frac{\delta b}{\frac{a}{b}M(W-w)} = \frac{\delta b^2}{aM(W-w)} > 0 \quad (12)$$

and

$$\text{tr}J = -b - \frac{\delta}{U} = -\left(b + \frac{\delta b}{aM(W-w)}\right) < 0 \quad (13)$$

Given that the trace of the Jacobian is negative and the determinant of the Jacobian is positive, we know that the long-run equilibrium is stable. However, it remains unclear whether it is a stable node or a stable focus. If the following inequality holds, we have a stable node,

$$(\text{tr}J)^2 \geq 4\mid J \mid \Leftrightarrow b^2 + \frac{2\delta b^2}{aM(W-w)} + \frac{\delta^2 b^2}{(aM(W-w))^2} - \frac{4\delta b^2}{aM(W-w)} \geq 0 \rightarrow 1 + \frac{\delta^2}{(aM(W-w))^2} \geq \frac{2\delta}{aM(W-w)} \quad (14)$$

When $(\text{tr}J)^2 < 4\mid J \mid$, we have a stable focus.

Figure 1 shows the short-run dynamics of convergence toward the long-run equilibrium (i.e., U^*,S^*). Assuming the equilibrium is a stable focus, the two most likely initial conditions are $U < U^*,\ S < S^*$, and $U > U^*,\ S < S^*$. In the former condition, the urban area is not yet a megacity, and the problems associated with pollution, environmental degradation, and other agglomeration costs are still manageable. The convergence toward the long-run steady-state equilibrium is characterized by an increase in both U and S. In the latter condition, $U > U^*,\ S < S^*$, because of city gigantism, the approach toward long-run equilibrium entails a decrease in city size while the service sector grows steadily. Put differently, in this case, the costs associated with city gigantism are sufficiently high that a share of the city's inhabitants prefers to leave the city and migrate to other places; meanwhile, the city is transformed from an industrial base toward a service-oriented city. Lastly, the convergence toward the long-run equilibrium described in Figure 1 can be related to the literature on smart, sustainable cities [25].

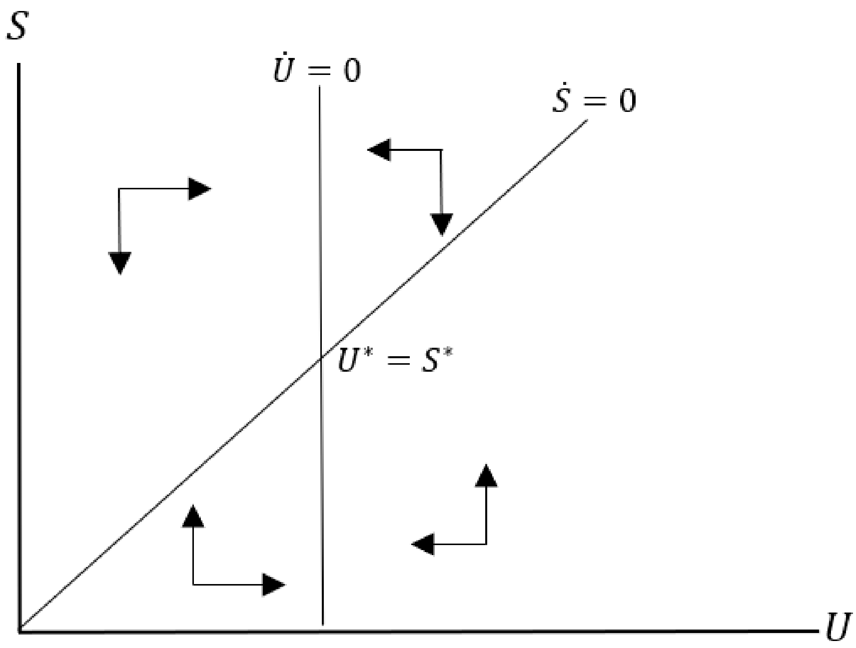

Figure 1. Short-Run Dynamics and Long-Run Steady-State Equilibrium.

4. Considerations for Future Research

At present, the theoretical model presented above yields credible and fundamental hypotheses, thus addressing the undertheorized literature on labor market sustainability in the Harris–Todaro tradition. Of course, empirical tests of those hypotheses would make our contribution whole. Future research based on our model would naturally include empirical studies estimating its short-run dynamics and long-run equilibrium. In doing so, these studies might consider the segment of services and education in relation to agriculture and anticipate the relocation of industry and services to rural areas. If one compares, for example, the share of employed persons and the creation of GDP in European countries, agriculture is a marginal factor in migration. This approach might also occur in the context of the Industry 4.0 concept and the expected general growth in the share of the services segment.

Other theoretical extensions of the Harris–Todaro framework described above might consider elements of the regulatory capture literature that are based on the seminal work by Stigler and Friedland, Stigler, Peltzman, and others [26–28]. Although much of this literature is focused on regulatory capture and/or bureaucratic delay in electric and other utilities [29–33], accounting, finance and corporate affairs [34–38], and healthcare [39–41], a stream of it focuses on the capture of environmental regulators by municipalities and their corporate agents [38,42–47]. The ability of special interests connected to municipalities to mitigate environmental cleaning and agglomerations costs associated with infractions cited by environmental regulators, either through avoiding such citations or lobbying for reduced penalties once a citation occurs, could impact the short-run dynamics explained in our stylized model. In addition, it is worth examining the role of government investments in infrastructure, which include pollution abatement and cleaning, in order to create new businesses [48–51].

Iterations of our extensions of the Harris–Todaro framework might also address other forms of environmental degradation associated with growing urbanization and megacities. These include, but are not limited to, noise pollution associated with airports and other infrastructure that accompany urbanization [52–54]. Additionally, issues associated with gang-related violent crime [55] and property crimes affiliated with large-city amenities, such as sporting events [56,57] and tourist attractions [58], also present opportunities for modifying our extensions of the Harris–Todaro framework described above. Building upon new work by Yu and Chow [13] by modeling growing income inequality in urban centers [59,60] would also advance the literature in this area of economics.

5. Conclusions

The mass migration from rural areas to industrial centers (due to industrialization), and the growth of the services sector reducing the relative size and importance of the industrial sector (due to investments in education) that have characterized much of the developing world over the past several decades, have predictably impacted the environment in two ways. The transition associated with rural–urban migration due to industrialization has predictably had a negative impact on the environment, while the transition from an industrial economy to a service economy has predictably had a positive cleaning effect on the environment. In order to analyze these theoretical impacts on the environment, this study formalizes both the short-run dynamics of these transitions as well as the long-run steady-state equilibrium.

Our model follows the Harris–Todaro framework by assuming that rural–urban migration is an increasing function of the wage differential between industry and agriculture and extends the same logic to the transition from an industrialized to a service-centered economy. The paper studies the short-run dynamics and the long-run equilibrium in which labor markets are linked to environmental issues such as environmental degradation, agglomeration costs, and cleaning costs. According to the short-run dynamics of the model, urban growth is affected positively by the growth rate of migration and by the industry-rural wage differential, as in [20], while it is negatively impacted by environmental degradation and agglomeration costs and by the city size, as indicated in [14–16]. Moreover, service sector growth is affected positively by the growth rate of education, as in [21], the services-industry wage differential, and the city's size, while it is negatively impacted by cleaning costs and service sector size with respect to city size.

The long-run optimal size of the city is an increasing function of migration, while it is a decreasing function of environmental degradation and agglomeration costs. Finally, the long-run optimal size of the services sector is an increasing function of migration, the migration growth rate, education, and the education growth rate, while it is a decreasing function of environmental degradation, agglomeration costs, and cleaning costs. As these environmental issues are of critical importance in long-run equilibrium, the main practical implication of the model is that the optimal city size ultimately depends on sustainability.

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