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GLOBALIZATION AND THE SKILLED CITY*

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Abstract

The location of economic activity both across and within countries has undergone dramatic shifts over the last five decades. Three key trends stand out. First, cross-country inequality has declined as many developing countries have grown rapidly. Second, economic geography within countries has instead grown more unequal in both the developed and the developing world. Third, within-country spatial disparities have grown mainly because of the disproportionate success of skilled cities. In this paper, I develop a model that jointly explains these patterns as a consequence of deepening international economic integration. My model explains the faster population and output growth of skilled cities, as well as their tendency to increase their initial skill advantage. Consistent with the evidence, my theory predicts a non-monotonic path of urban growth in developed countries. The model predicts a future shift in worldwide urban hierarchies as some developing-world cities overtake unskilled cities in industrialized countries along global supply chains.

JEL classification: F1, O1, R1

Keywords: globalization, urbanization, urban growth, skilled cities

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1 Introduction

Economic geography has changed dramatically over the last five decades, both across and within countries. Rapid export-led growth in many developing countries, particularly China and India, has led to a more dispersed cross-country economic geography. By contrast, within-country economic geography has instead grown more unequal[1]. In developed countries such as the US, economic convergence across regions has stopped and may have even reversed. Urban success has been uneven: some cities experienced rapid growth while others suffered stagnation or even decline. Spatial disparities have also widened in developing countries where economic growth propelled the rise of superstar cities but left many areas almost untouched.

Human capital has emerged as a key determinant of diverging urban fortunes. Skilled cities have outperformed their skill-scarce counterparts on most measures of urban growth, including population growth and real estate appreciation (Glaeser 1994; Glaeser, Scheinkman and Shleifer 1995; Simon and Nardinelli 1996,2002; Black and Henderson 1999; Glaeser and Saiz 2004; Shapiro 2006; De la Garza 2008; Liao 2010).[2] These skilled locations have also widened their skill advantage over recent decades, leading to skill polarization across space (Berry and Glaeser 2005). This link between human capital and urban success has been documented for rich and poor countries alike (Anderson and Ge 2004; Da Mata et al. 2007; Queiroz and Golgher 2008).[3]

What has caused this reconfiguration of economic geography both across and within countries? This paper advances the hypothesis that the reshaping of global supply chains brought about by deepening globalization can jointly explain these observed patterns. I develop a model in which the reduction of international trade costs allows middle-skill activities (such as advanced manufacturing, product testing etc.) to be increasingly separated from high-skill functions (such as management, R&D or other advanced services). As a result, middle skill activities are increasingly outsourced to low-wage countries while high-skill functions remain the preserve of developed countries[4]. This reshaping of global value chains can account for the rapid economic growth of developing countries like China and India, the decline of the US rust belt, the resurgence and continued success of leading cities like New York and London, and the rise of superstar cities in the developing world[5].

My model features a simple geography. There are two countries, North (N) and South (S). Each country has a population of ex-ante identical workers who can choose to acquire skills. Workers cannot move across countries, but they are perfectly mobile within their country. Each country consists of two cities and a non-urban hinterland. All locations are characterized and by their Ricardian productivity, which in the case of cities is interpreted as urban infrastructure. Cities are also characterized by their endowments of scarce urban land. The hinterlands are fully specialized in a traditional unskilled sector. Cities host instead three other activities:

[1] Moretti (2012) calls this phenomenon "The Great Divergence"

[2] The relationship between human capital and local productivity and economic success is explored at length in Moretti (2004,2013).

[3] As is standard in the literature, here and elsewhere I use the concept of skilled cities to mean urban areas with a (relatively) high fraction of their populations exceeding a certain threshold of skill or education level.

[4] The main mechanism highlighted by the model places this paper in the wider literature on offshoring (McLaren 2000; Grossman and Helpman 2002, 2004, 2005; Antras 2003; Antras and Helpman 2004; Antras, Garicano and Rossi-Hansberg 2006) and global supply chains (Feenstra and Hanson 1996; Jones and Kierzkowski 1990, 2001; Deardoff 2001*a*, 2001*b*; Kohler 2004; Fujita and Thisse 2006; Grossman and Rossi-Hansberg 2008; Baldwin and Robert-Nicoud 2014)

[5] By relating the elimination of spatial frictions to trade to the evolution of within country economic geography this paper contributes to the strand of literature analyzing the impact of international trade integration on intra-country economic geography (Krugman and Livas Elizondo 1996; Paluzie 2001; Monfort and Nicolini 2001; Behrens, Gaigne, Ottaviano and Thisse 2006*a*, 2006*b*, 2007, 2009)

unskilled manufacturing, skilled manufacturing, and management services. These activities are simultaneously ranked by increasing skill intensity, decreasing land intensity, and increasing reliance on urban infrastructure.

Management plays the pivotal role in shaping global value chains. It has three key properties. First, it is concentrated in a single Northern city because it is subject to strong agglomeration economies and a wide North-South productivity gap. Second, it serves as an intermediate input for the other urban activities, and is more important for skilled than for unskilled manufacturing. Third, it is costly to deliver across countries. The cost of international trade in management services declines with improvements in information and communication technology, such as the advent of cell phones, the internet and email. With this decline in communication costs as its single driving force, my model matches qualitatively the main features of the evolution of global economic geography over the last four decades.

Starting with prohibitive communication costs, the model reproduces the economic geography of the middle of the twentieth century. The wealthy North has successful and differentiated cities while the lagging South has small and undifferentiated cities. Management clusters in only one city which becomes the North's skilled city. High communication costs force skilled manufacturing to co-locate with management in the North. Southern cities fully specialize in unskilled manufacturing which accounts for only a small share of the urban value chain.

As communication costs decline, the Southern city with better infrastructure becomes competitive in skilled manufacturing and gradually captures market share in this activity. The re-location of skilled manufacturing from North to South induces income convergence between the two countries. It also increases the average skill intensity of the activity mix in both countries. This increase in the demand for skill is met by endogenous skill acquisition. The leading city in each country, which has a comparative advantage in the more skilled activity, grows both in absolute terms and relative to its less skilled counterpart. This differential growth induces economic divergence across cities within each country. Skilled cities concentrate an increasing share of their countries'population and output.

Moreover, as the growing skill intensive sectors locate disproportionately in each country's leading city, these cities become increasingly specialized in their country's most skilled activity and disproportionately attract skilled workers. This increasing specialization induces intra-national skill polarization across cities. Finally, as the spatial reallocation of the urban supply chain reduces the cost of urban output relative to the traditional good produced in the hinterlands, elastic final demand implies that the worldwide urban sector grows relative to the traditional one. This growth pattern accounts for the worldwide advance of urbanization driven primarily by the South.[6]

In addition to matching the motivating facts, my model reproduces the non-monotonic path followed by skilled cities in many developed countries, with stagnation or even decline followed by rapid urban resurgence (Glaeser and Ponzetto 2010). The model can also be used to anticipate the effects of further reductions in spatial frictions across countries. In particular, a fall in communication costs below a critical threshold may

[6]The structural transformation mechanism embedded in my model is conceptually closest to studies analyzing urbanization and structural transformation in the context of open economies (Glaeser 2013, Fajgelbaum and Redding 2014, Jedwab 2014). This feature of the model also places the current paper in the wider literatures on urbanization (Kim 2000; Kim and Margo 2004; Michaels, Redding and Rauch 2011, 2012, 2013) and structural transformation (Baumol 1967; Ngai and Pissarides 2007; Rogerson 2008; Gollin, Parente and Rogerson 2002, Matsuyama 1992).

lead to "urban overtaking" along the global supply chain. In this scenario, the skilled city in the South obtains a more skill intensive industrial composition than the unskilled city in the North, and also surpasses its land valuations. This novel theoretical result already seems relevant for the most successful developing world cities and highlights a mechanism that helps explain the recent phenomenon of "reshoring".

The rest of the paper is structured as follows. The next section briefly reviews the evidence that documents the motivating facts. Section 3 outlines the model and presents the main results. Section 4 presents a more detailed account of the recent "history of the location of economic activity" as seen through the lens of the model. Section 5 concludes.

2 Reviewing the Facts

This paper aims to explain the following stylized facts, in a unified framework that permits the study of developments in both industrialized and developing nations: (1) in recent decades cross-country economic geography has experienced some rebalancing as a group of developing countries has grown rapidly and caught up with industrialized countries; (2) world urbanization has increased sharply, mainly driven by unprecedented rates of urbanization in the developing world; (3) within countries, economic activity has instead become more concentrated as cities with higher endowments of human capital have performed better along most measures of urban success, including population growth, employment growth, income growth and real estate price appreciation; (4) also within countries, a phenomenon of skill polarization across space has been documented, as skilled cities have augmented their skill advantage over their skill scarce counterparts. In this section, I review the supporting evidence for these facts.

Panel a of Figure 1 illustrates our first stylized fact. In the last five decades, rapid growth in some large developing countries (primarily China and India, but also Brazil, Indonesia, South Africa, Turkey and Vietnam) has led to a reduction of global income inequality. This has occurred in spite of an increase in inequality within countries and even in the face of disappointing growth performance in other poor countries (Sala-i-Martin 2006). In turn, this development has had a profound implication for the spatial distribution of economic activity across countries. A simple reading of international GDP statistics serves as a compelling illustration of this fact. As recently as 1992, the advanced group of industrialized economies within the G20 represented almost 60% of world GDP at PPP, whilst the group of emerging economies within the same club represented 20% of world GDP. By 2014, the group of advanced economies within the G20 accounted for only 46% of world GDP at PPP, while the share of the G20 emerging economies had increased to 36%[7].

The reconfiguration of cross-country economic geography has been accompanied by a process of rapid urbanization, which has led to increasing concerns about issues such as sustainability and the emergence of excessive concentrations of population. Panel b of Figure 1 illustrates this development. If in 1960 only 33.6% of the world's population lived in cities, by 2010 a majority of the world's population (51.5%) resided in urban areas. The shift towards urban living was particularly strong in less developed countries, which increased their

[7]Reported data based on the IMF's World Economic Outlook Database.

urbanization rate from 23.6% to 46% over this period. The scale of this phenomenon has led some analysts to conclude that some of the mechanics of the urbanization process have changed, as many nations are now able to sustain high levels of urbanization at lower levels of income than was typical in the past (Glaeser 2013). This view is also supported by the weakening of the traditional links between urbanization on one hand and industrialization (Gollin, Jedwab and Vollrath 2015) and growth (Jedwab and Vollrath 2015) on the other. Nevertheless, urbanization also continued in the world's advanced regions, where the proportion of population living in cities increased from 64% to 80% over the last half a century.

Against this backdrop of cross-country economic convergence, recent decades have also witnessed widening spatial disparities within countries. This trend has been particularly salient at the urban level, where growth performance has been highly heterogeneous[8]. Interestingly, the diverging fortunes of cities seem to have been partially driven by a growing association between human capital and urban success. This has been reflected in two related developments affecting both developed and developing countries: skilled cities have displayed superior performance across a battery of measures of urban growth and they have also augmented their skill advantage over time, a phenomenon described as "skill polarization across space". I illustrate these two trends, which form the object of my final two stylized facts of interest, for the case of the US and China in Figure 2. Panels a and b of Figure 2 document the faster population growth of skilled cities in these two countries in the last decade of the twentieth century, while panels c and d document the phenomenon of skill polarization across space over the same period.

The fact that local human capital endowments have been a strong predictor of urban growth over recent decades in both rich and poor countries has been extensively documented in the literature. Analyzing a large sample of US metropolitan statistical areas (MSAs) over the period 1980 to 2000, Glaeser and Saiz (2004) find that a 1 percentage point increase in the share of a city's adult population with a bachelor's degree is associated with an increase in the decadal population growth rate by about half of one percent. In a similar study, Shapiro (2006) finds that over the period 1940 to 1990 a 10% increase in a metropolitan area's concentration of college educated residents was associated with a 0.8% increase in subsequent employment growth. Glaeser, Ponzetto and Tobio (2012) also confirm the link between skills and regional growth for US counties over the last two centuries, though the correlation seems to break down for parts of the nineteenth century. Similarly, a long-run study of UK cities undertaken by Simon and Nardinelli (1996) finds a robust connection between initial human capital endowments and subsequent city growth for a period spanning over a century. For the case of developing countries, Da Mata et al. (2007) analyze a large sample of Brazilian cities and find that an increase by one year in the average number of years of schooling at the city level is associated with a 5.6% increase in the decadal population growth rate.

Similarly, the phenomenon of skill polarization accross space benefits from substantial empirical support. In an analysis of the evolution of skill shares across a sample of more than three hundred US metropolitan areas over the period 1990 to 2000, Berry and Glaeser (2005) find that a one percentage point increase in the

[8]For example, for the case of the US, Glaeser and Ponzetto (2010) document that while San Francisco and Chicago have added substantially to their populations in the period spanning 1970 to 2010 (17% and 13% respectively), Detroit has lost more than 20% of its population in the same period.

proportion of city's population holding a bachelors degree in 1990 is associated with a 0.13 percentage point increase in the growth of the city's skill share over the next decade. Comparable results have been found by Poelhekke (2013) for the case of Germany and by Queiroz and Golgher (2008) for Brazil.

3 Model

3.1 Basic Setup

The model describes the process through which the reduction of cross country spatial frictions leads to the reallocation of economic activity across and within countries and explains the recent changes in the configuration of economic geography. I interpret these spatial frictions as (international) communication costs that decline with improvements in information and communication technology, such as the advent of cell phones, the internet and email[9]. While this decline in communication costs is the single driving force of globalization in my model, other potential drivers of globalization (such as international financial integration, cross-country technological diffusion or reductions in trade costs due to trade liberalization) could be modeled in the same way and have similar implications for global value chains and for economic geography.

I consider a set-up with a simple geography: a world economy featuring two countries, labeled North (N) and South (S). Each country contains two urban locations (or cities) and a hinterland or countryside. The cities are indexed $N1$ and $N2$ in the North and $S1$ and $S2$ in the South. Cities are described by their endowments of land which I denote by N^{cn} and by their location specific Ricardian productivity, which I interpret as infrastructure and denote by A_{cn}[10]. For simplicity I assume that all urban locations in both North and South have an identical endowment of land $N^{S1} = N^{S2} = N^{N1} = N^{N2} = \overline{N}$. Land is owned by absentee landlords.

Countries have exogeneously given populations of ex ante identical workers L^N and L^S. As is standard in the international trade and economic geography literatures, I assume that workers are immobile internationally, but are costlessly mobile across locations within countries. Workers in both countries have a unit endowment of time and have access to an educational technology that allows them to acquire skills at the expense of fraction $e < 1$ of their time[11].

Two consumption goods are produced in the world economy: a traditional good, indexed as good 1, which is produced in the hinterland, and an urban good, which is indexed as good 2. The delivery of the urban good requires the completion of multiple production stages: unskilled manufacturing, skilled manufacturing, and management (or management services). These production stages have a natural ranking by skill intensity, with management being the most skill intensive activity in the world economy. All commodities (i.e. both final goods and intermediates or production stages) in the world economy are produced under conditions of perfect

[9]This is line with several strands of literature that have attributed phenomena as diverse as the changing patterns of economic specialization across US cities (Duranton and Puga 2005), the reorganization of cross-country teams (Antras and Garicano 2006) and the changing nature of international trade (Baldwin 2016) to improvements in communication technologies.

[10]In my setting, infrastructure may reflect both history determined investments in roads, rail or other types of productivity enhancing immobile capital as well as "first-nature" factors (i.e. natural advantage) such as proximity to the coast or to major rivers.

[11]Importantly, the educational technology is assumed to be identical across countries.

competition.[12]

The organization and spatial configuration of global value chains is critically shaped by management. This is because this activity has three main distinguishing characteristics. First, management is the only activity subject to agglomeration economies, which are assumed to have the nature of localization economies. In keeping with empirical evidence, this assumption captures the fact that skill intensive activities are typically subject to stronger agglomeration economies than more basic ones[13]. Thus, the production of management involves combining land and labor via the technology:

$$M^{cn} = \phi\left(\frac{M^{cn}}{M}\right)[A_{cn}^{\rho} H_M^{cn}]^{\mu'}\left[(A_{cn} L_M^{cn})^{\beta}(N_M^{cn})^{1-\beta}\right]^{1-\mu'} \quad (1)$$

where c and n index countries and cities respectively, L denotes unskilled labor, H denotes skilled labor, N denotes urban land while α, β, μ' and ρ are parameters, with $\alpha, \beta, \mu' < 1$ and $\rho > 1$. Localization economies are formalized by the productivity shifter $\phi(\frac{M^{cn}}{M})$ with the property that $\phi'(.) > 0$[14]. In essence, a city's productivity in delivering management services is a function of its global market share in the management sector.

Second, management is the only commodity that is subject to spatial frictions, represented in our setting by international communication costs[15]. Management services face negligible communication costs within countries, but substantial such costs when delivered internationally. Communication costs take the standard iceberg form: $\tau > 1$ units of the management services need to be shipped from a location within country c for one unit of such services to be delivered to a city within country c'. By contrast, all other commodities are assumed to be costlessly tradable both within and across countries. This set of assumptions captures the declining importance of physical transportation costs for goods and services relative to the costs of transporting ideas and people (Glaeser and Kohlhase 2004) as well as the fact that persistently high costs of transferring knowledge and ideas are more consequential for interactive, skill- and idea-intensive activities (Glaeser and Ponzetto 2010, Michaels, Rauch, Redding 2013).

Third, management does not enter the production of the urban good directly, but as an input in the skilled manufacturing stage of production. This assumption captures the intuition that more sophisticated production stages typically require greater managerial attention than more basic production activities. For example, manufacturing workers in the apparel sector require less managerial input than product designers, while in the software industry programmers require more contact with software developers and project managers than

[12] These production stages can be reinterpreted as intermediate goods, so that I sometimes refer to the production stages as intermediates.

[13] The assumption that skill intensive activities are subject to stronger agglomeration economies is standard in the literature (Glaeser and Ponzetto 2010) and benefits from empirical support (Henderson 1983, Nakamura 1985, Henderson et al. 1995, Dumais et al. 2002, Alonso-Villar, Chamorro-Rivas and Gonzalez Cerdeira 2004).

[14] A framework employing urbanization economies generated by human capital would generate similar results to the present framework but would be more algebraically cumbersome. Moreover, the empirical literature in urban economics finds stronger evidence in favor of localization economies than urbanization economies. See for instance Nakamura (1985), Henderson (1986), Rosenthal and Strange (2004), Henderson (2003).

[15] I interpret communication costs as any costs related to managing or providing advanced services to a plant located remotely. They could include the opportunity cost of time incurred when middle or top managers have to visit faraway plants, or the incremental fees paid to management consultants or other skilled external service providers when they have to visit and analyze such plants.

product testers.

The production of skilled manufacturing thus combines labor, land and management via the technology

$$s^{cn} = \left[(A_{cn}^{\rho} H_s^{cn})^{\alpha} (M^{cn})^{1-\alpha} \right]^{\mu} \left[(A_{cn} L_s^{cn})^{\beta} (N_s^{cn})^{1-\beta} \right]^{1-\mu} \tag{2}$$

where c and n index country and city respectively, and the requirement that management is the most skill intensive activity in the world economy implies that $\mu < \mu'$. Moreover, the production of urban goods also requires unskilled manufacturing, which is delivered via the technology:

$$u^{cn} = [A_{cn} L_u^{cn}]^{\beta} [N_u^{cn}]^{1-\beta} \tag{3}$$

The production processes for the urban intermediates described above embed two important features. The first concerns the factor intensity of the various urban activities. Along the value chain of the urban good more skill intensive production stages are also less land intensive. This assumption is standard in the urban economics literature and is in line with empirical observations: Glaeser and Ponzetto (2010) employ the same assumption while Wood and Berge (1994) and Owens and Wood (1995) note that "Primary production is usually both more land-intensive and less skill intensive than manufacturing".

The second important feature concerns the role of infrastructure in production. In particular, infrastructure has a greater impact on output in the more skill-intensive production stages. This is because a given endowment of A units of infrastructure in a particular location enhances the productivity of unskilled workers in that location by a factor of A, but augments the productivity of skilled workers by a larger A^{ρ} (where $\rho > 1$). As a consequence, cities with high endowments of local infrastructure are particularly attractive for activities, such as management and skilled manufacturing, that make intensive use of skilled labor.

The urban good is assembled from the unskilled manufacturing intermediate and the skilled manufacturing intermediate via the production process:

$$q_2 = u^{\theta} s^{1-\theta} \tag{4}$$

where u denotes unskilled manufacturing and s denotes skilled manufacturing. In line with empirical observation we assume that the more skill intensive stage of production of the urban good contributes disproportionally to its value by setting $\theta < \frac{1}{2}$ (Moretti 2013)[16].

Finally, production of the traditional good takes place in countries' hinterlands and employs unskilled workers via the linear production technology

$$q_1^c = \xi_{1c} L_1^c \tag{5}$$

where ξ_{1c} denotes the productivity with which the traditional good is produced in country $c \in \{N, S\}$.

On the demand side of the model, the preferences of the representative consumer (worker or landowner) are

[16] Analyzing the often discussed case of the iPhone, Moretti(2013) notes:"The iPhone is made up of 634 components. The value created in Shenzen is very low, because assembly can be done anywhere in the world[...]The majority of the iPhone's value come from the original idea, its unique engineering, and its beautiful industrial design."

defined over consumption of the urban and traditional goods, and are characterized by the utility function

$$U(q_1, q_2) = \left[\gamma q_1^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma) q_2^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{6}$$

Workers choose their location, occupation and consumption to maximize utility. In line with our description of production technologies and geography, they face three career-location options: to remain in the hinterland and work in the traditional sector, to move to an urban location within their country and work as an unskilled worker in the urban sector, or to acquire skills and move to an urban location to work as a skilled worker in the urban sector. Crucially, we require that the elasticity of substitution between the two final goods in consumption is greater than unity (i.e. $\epsilon > 1$), which means that producers of each good face elastic demand.

3.2 Equilibrium Definitions

With the set-up above, an equilibrium of the world economy can be defined as follows:

Definition 1. *A (world) equilibrium is an allocation of workers across locations and sectors* $\left\langle L_1^S, H_i^{S1}, L_i^{S1}, H_i^{S2}, L_i^{S2}, L_1^N, H_i^{N1}, L_i^{N1}, H_i^{N2}, L_i^{N2}\right\rangle$ *with* $i \in \{u, s, M\}$*, a collection of factor prices* $\left\langle w_S^S, w_S^U, w_N^S, w_N^U, r_{S1}, r_{S2}, r_{N1}, r_{N2}\right\rangle$ *and a collection of commodity prices prices* $\langle p_1, p_u, p_s, p_M\rangle$ *such that:*

- *consumers are maximizing utility by their choice of location, occupation and consumption*
- *firms in all sectors - unskilled manufacturing (u), skilled manufacturing (s) and management services (M) - are maximizing profits by their choice of location and input mix*
- *labor markets clear at each location for each type of labor*
- *land markets clear at the city level*
- *markets for all goods and intermediates, including management services clear at the level of the world economy.*

External effects (localization economies) generate the possibility of multiple equilibria[17]. I deal with this issue following the standard approach in economic geography. I define a concept of equilibrium stability and focus my analysis on stable equilibria. Intuitively, a world equilibrium is stable if it is robust to a locational deviation by a small but positive mass of management services providers. As management is the only activity subject to external economies, it is the only source of multiple equilibria. My definition of equilibrium stability is stated more formally below:

Definition 2. *A (world) equilibrium is stable if it tends to be restored after a small set of management services producers is moved exogenously from one location to another. A deviation is "small" if the cumulative market*

[17] Multiple equilibria are a standard feature in modern economic geography models. For example, while the presence of (sufficiently strong) localization economies tends to favor the agglomeration of the management services production in only one urban location, there always exists symmetric equilibria in which multiple cities host an equal fraction of the management services sector. For a brief discussion of this issue see Krugman (1998).

share of the deviating firms is not sufficient to reverse or tie the ranking by market share in management of any pair of urban locations .

3.3 Parameter Restrictions

To match empirically relevant configurations of economic geography I impose additional parametric restrictions on the set-up described above. These are outlined as Assumptions 1 to 5 below[18]. Taken together, they generate four key features of the economic environment.

First, I require that the North takes on the role of the high wage country and displays a comparative advantage in the most skill intensive activity, management. This is implemented via the following two assumptions:

Assumption 1 **- North- South Wage Gap -** Northern productivity in the traditional sector is higher than that of the South ($\xi_{1N} > \xi_{1S}$), and the traditional sector is sufficiently large (i.e. γ is sufficiently large) such that in any equilibrium the traditional good is produced in both countries.

Assumption 2 **- Comparative Advantage in Management -** Management services can only be produced in the North.

Assumption 1 guarantees that the relative wages between the two countries are fixed by their relative productivity in the traditional sector. Moreover, since we assume that the North is more productive in this activity, it becomes the high wage country in our setting. Importantly, the location of urban activities and the (changing) patterns of comparative advantage in the urban sector have no bearing on the relative wages of the two countries. This approach to fixing relative wages between countries ensures the tractability of our analysis and is widely used in the international trade literature (see Antras and Helpman 2004).

Assumption 2 gives the North an overwhelming comparative advantage in the production of management. This admittedly stark assumption aims to capture the fact that while developing economies have recently diversified into increasingly complex activities, the most sophisticated stages of global value chains (such as the high-level management of large multinationals, but also complex finance and technology functions) have largely remained the preserve of rich nations.

Second, I require that the localization economies are sufficiently strong to ensure the clustering of this activity in only one urban location:

Assumption 3 **- Agglomeration Economies and the Clustering of Management -** Localization economies in management are sufficiently strong ($\phi(.)$ is sufficiently convex) that any stable equilibrium features the clustering of management in only one urban location.

Given my earlier assumptions about cross-country comparative advantage in management, Assumption 3 guarantees that any stable equilibrium features the complete clustering of the management sector in one of the North's cities. This assumption aims to parsimoniously capture the empirical observation that the most skill intensive activities along global value chains have traditionally concentrated in a small number of successful locations within rich nations.

[18] The formal statements of the parametric restrictions are provided in Appendix *A*. A brief discussion of the robustness of the model's predictions to relaxing some of these restrictions is provided in Appendix *C*.

Third, I assume that infrastructure plays a crucial role in the delivery of skilled manufacturing and that infrastructure endowments are heterogeneous in the South. Infrastructure is typically relatively abundant in rich nations but is scarce in many parts of the developing world. Moreover, it can be a significant driver of spatial disparities within developing nations, as cities and regions with more developed infrastructure (or better market access) are often able to undertake high value added activities while lagging locations within the same countries are precluded from doing so. To capture this feature of observed economic geography I assume:

Assumption 4 **- Infrastructure Heterogeneity and the Role of Infrastructure in Production** - Northern locations have high and homogenous endowments of infrastructure given by $A_{N1} = A_{N2} = A > 1$. By contrast the South displays heterogeneous infrastructure endowments: an advanced city (which we assume to be $S2$) has abundant infrastructure comparable to that of Northern locations $A_{S2} = A > 1$ while the other Southern location is characterized by a low infrastructure endowment $A_{S1} = 1$. Moreover, the role of infrastructure in skilled manufacturing is sufficiently important (i.e. ρ is sufficiently large) such that the lagging Southern city can never be a lowest cost location for the completion of skilled manufacturing.

Finally, as the model aims to analyze the implications of globalization for the distribution of economic activity across space, I require that the presence of international communication costs imposes a binding constraint on the production possibilities of the South. I thus impose the following restriction:

Assumption 5 **- Communication Costs and Comparative Advantage** - The North-South wage gap is sufficiently large (i.e. ξ_{1N}/ξ_{1S} is sufficiently large) such that in the absence of communication costs some Southern locations have a comparative advantage in the completion of skilled manufacturing [19].

The assumption above guarantees that changes in communication costs have the potential to shift the patterns of comparative advantage and lead to the reallocation of economic activity across space. This is because in the absence of communication costs some Southern locations are posited to be competitive in skilled manufacturing, while the presence of high communication costs can reverse this pattern of comparative advantage in favor of the North by raising the Southern price of a crucial input for skilled manufacturing - management.

3.4 Spatial Equilibrium and Main Results

With the above restrictions in place, the model can account for some of the key facts that characterize the evolution of global economic geography in the last five decades. In this section I outline the main predictions of the model and relate them to the stylized facts that motivate the paper. In the next section I present a more detailed, stage by stage account of the history of the location of economic activity as seen through the lens of the model.

With perfectly competitive markets for all commodities, spatial equilibrium requires that all activities in

[19] Two versions of this assumption (denoted Assumptions $5a$ and $5b$) are maintained during different parts of our analysis, with one being more restrictive. The less restrictive Assumption $5a$ is sufficient for the results reported in this section, while in section 4 the more restrictive Assumption $5b$ is maintained. For more details see Appendix A.

the world economy take place at cost minimizing locations:

$$p_i = \min_l c_l(i) \ \forall i \in \{1, u, s, M\} \tag{7}$$

where l indexes locations (i.e. the hinterlands of the two countries and cities $S1, S2, N1, N2$). Communication costs result in different prices for management services in the North and South:

$$p_S^M = \tau p_N^M \tag{8}$$

where τ represents international communication costs. The prices of all other commodities are identical both across and within countries.

Regarding factor prices, perfect mobility guarantees that wages are equalized across locations within countries for workers of the same skill level. Assumption 1 fixes the level of unskilled wages in both North and South:

$$w_c^U = \xi_{1c} p_1 \ c \in \{N, S\} \tag{9}$$

Furthermore, access to educational technologies that allow workers to acquire skills fixes the equilibrium skill premia in both countries. As these educational technologies are assumed to be identical across countries the skill premium in both North and South is given by:

$$w_c^S = \frac{w_c^U}{1-e} \tag{10}$$

Equation (10) clarifies an important feature of the model: factor proportions play no role in determining the patterns of comparative advantage across countries. As workers are (ex-ante) identical and skill acquisition is endogenous the price of skill in both countries is solely determined by their respective education technologies. Moreover, as these education technologies are assumed to be the same across countries, the relative price of skill also plays no role in determining the location of economic activity across countries. In effect, the only determinants of economic geography in my framework are Ricardian productivity differences (described in Assumptions 1 to 5) and the existence of spatial frictions (communication costs).

Moving to urban land markets, rental rates in each city are pinned down in equilibrium by the condition

$$r_l \bar{N} = (1-\beta)Y_u^l + (1-\beta)(1-\mu)Y_s^l + (1-\beta)(1-\mu')Y_M^l \tag{11}$$

The income of landowners at each urban location is thus given by the land rental expenditures of the economic activities housed by each city (Y_i^l denotes the value of output of commodity i produced at location l). Furthermore, each city's equilibrium population and skill share are given by the scale and composition of the activity mix it contains:

$$Pop_l = \sum_{i\in\{u,s,M\}} L_i^l + \frac{1}{1-e} \sum_{i\in\{u,s,M\}} H_i^l \tag{12}$$

$$\frac{H^l}{L^l} = \frac{\frac{1}{1-e}\sum_{i\in\{u,s,M\}} H_i^l}{\sum_{i\in\{u,s,M\}} L_i^l} \tag{13}$$

With these preliminaries in place, we are ready to study the effect of improvements in long-distance communication, reflected in the decline of τ, on the spatial configuration of economic activity. We are particularly interested in changes in cities' populations, skill shares and real estate prices, as well as in urbanization.

I begin by considering the case of prohibitively high communication costs affecting the international delivery of management services. This setting represents the world economy in the middle of the twentieth century, when containerization and other technological developments had already lowered the costs of shipping goods over long distances, but communication costs remained high and multinationals were rare. Proposition 1 offers a snapshot of economic geography under these circumstances.[20]

Proposition 1. *There is a threshold of communication costs T_{max} such that if*

$$\tau > T_{max}$$

there is a unique stable equilibrium. Both Southern cities are specialized in unskilled manufacturing (u). One Northern city ($N1$) is fully specialized in skilled manufacturing (s). The other ($N2$) provides both skilled manufacturing and management services (M). In the South, the more advanced city $S2$ is larger ($Pop_{S2} > Pop_{S1}$), has greater output ($Y_{S2} > Y_{S1}$) and higher land prices ($r_{S2} > r_{S1}$). In the North, the city where management clusters ($N2$) is larger ($Pop_{N2} > Pop_{N1}$), has greater output ($Y_{N2} > Y_{N1}$) and a higher skill share ($\frac{H_{N2}}{L_{N2}} > \frac{H_{N1}}{L_{N1}}$).

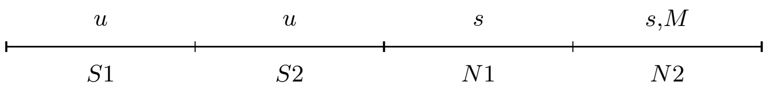

Figure 3: World before communication-induced integration

When communication costs are very high, skilled manufacturing is uneconomical to produce in the South . This is because it requires management as an essential input, which in turn is very costly to source from the North and infeasible to produce in the South (Assumption 2). As a result, the equilibrium features a relatively poor South whose cities are completely specialized in unskilled manufacturing, and a richer North that undertakes both skilled manufacturing and management. Southern cities are relatively undifferentiated, displaying the same skill share and industrial structure. However, the more advanced city in the South, $S2$, has a higher population and more expensive urban land than its counterpart $S1$ due to its greater endowment of infrastructure.

[20] All proofs are in Appendix B.

In the North, the clustering of management in only one urban location, $N2$, endogenously gives rise to cities that are differentiated in terms of both their industrial structure and their skill share[21]. $N2$ becomes the North's skilled city, while $N1$, which becomes fully specialized in skilled manufacturing (s), takes on the role of the relatively unskilled Northern city. Due to the lower land to labor ratio in the management sector, $N2$ has a larger population than its less skilled counterpart. However, given that Northern cities are identical in terms of both exogenous infrastructure and access to management, and that the sector that is on the locational margin between the two Northern cities is skilled manufacturing (s), the two cities of the North have the same rental rates for urban land.

In what follows, I explore the implications of gradually removing communication costs associated with the international delivery of management. Proposition 2 summarizes the model's predictions for urbanization and the cross-country distribution of economic activity:

Proposition 2. *Along the path defined by unique stable equilibria and for any $1 < \tau \leq T_{max}$, as communication costs decline the world economy grows, urbanization increases and the compensation of Southern factors relative to factors in the North weakly increases. Moreover, there is a threshold $\tau^* \geq 1$ such that for $\tau^* < \tau \leq T_{max}$, as communication costs decline, the aggregate compensation of Southern factors of production relative to Northern factors strictly increases.*[22]

As communication costs decline below a critical threshold (T_{max}), the patterns of comparative advantage begin to shift. The South becomes competitive in skilled manufacturing and captures market share in this activity. This allows the world economy to operate at higher levels of efficiency, as a friction is reduced and economic geography moves closer to a configuration determined solely by (unconstrained) comparative advantage. As a result, world output increases.

With skilled manufacturing increasingly undertaken in the South, the price of intermediate s and of the overall urban good fall relative to the price of the traditional good. Intuitively, this is because falling communication costs gradually remove a friction that affects the production of the urban good but not of the traditional one. Moreover, given elastic demand for the urban good, this results in an increase in the expenditure share of the urban good, and conversely a decline in the expenditure share of the traditional good. This movement in the relative expenditure shares of the two sectors (urban and rural) is reflected in their relative wage bills, and also in their relative employment levels. This entails a rise in the share of city dwellers as a proportion of total world population, or , in other words, an increase in urbanization.

Proposition 2 also predicts convergence in total output (or GNP) between North and South. Under Assumption 1, the relative wages and hence the relative aggregate wage bills of the two countries are fixed by their relative productivity in the traditional sector. However, as communication costs fall, a larger fraction of urban production takes place in the South and Southern urban landowners increase their share in overall

[21]The assumption that $N2$ is the location that captures the entire management sector is without loss of generality. The equilibria described are unique up to a permutation of Northern city labels.

[22]For some values of the model's parameters, there exists a threshold of communication costs τ^* below which further improvements in communication leave the compensation of Southern factors relative to Northern factors unchanged. This occurs because below this threshold, the possibilities for geographic reallocation of economic activity are extinguished.

land receipts. As a result, the overall compensation of Southern factors grows relative to that of the North. Finally, as worldwide urbanization increases and the South increases its weight in urban production, the size of the Southern urban system increases. Given that countries have constant populations, this implies that the urbanization rate of the South also increases.

The shifts in the location of economic activity caused by declining international communication costs affect not only the cross country distribution of income and urbanization, but also the relative size of cities within countries.

Proposition 3. *Along the path defined by unique stable equilibria, for any $\tau^* < \tau \leq T_{max}$, a reduction in τ is associated with an increase in the relative size of the skilled cities ($S2$, $N2$) in both the North $\left(\frac{\partial}{\partial \tau}\frac{Pop_{N2}}{Pop_{N1}} < 0\right)$ and the South $\left(\frac{\partial}{\partial \tau}\frac{Pop_{S2}}{Pop_{S1}} < 0\right)$.*

Proposition 2 revealed that as communication costs decline the South captures a larger fraction of the value chain for the urban good, and begins a process of catch-up relative to the North. This catch-up process does not proceed evenly, however. Due to its high infrastructure endowment, the advanced Southern city $S2$ benefits from the gradual relocation of skilled manufacturing from the North. By contrast, the lagging Southern location is precluded from gaining market share in this activity by its comparatively poor infrastructure. Thus, given the high employment density of skilled manufacturing, $S2$ displays more robust population growth than its lagging (and now relatively skill scarce) counterpart $S1$, causing the relative size of Southern cities to move in the direction described by Proposition 3.

The implications of this gradual relocation of skilled manufacturing from North to South are also not symmetric for locations in the North. As the South becomes increasingly competitive in intermediate s, both Northern locations gradually shed skilled manufacturing activities and their affiliated jobs. However, whereas $N1$ benefits from no compensating force against this loss of market share in skilled production, this is not the case for $N2$. A fall in communication costs is associated not only with skilled production relocating to the South, but also with an increase in the overall size of the urban sector. Thus, while the North-South reallocation of activity negatively impacts both Northern cities, the management cluster in city $N2$ stands to benefit from the lowering of communication frictions, as it can now sell its product to a larger and more efficient world economy. This growth of management services then serves to cushion the negative impact of skilled manufacturing relocation for city $N2$ in the early stages of globalization and eventually allows for $N2$ to grow even in the face of substantial offshoring to the South. This ensures more robust population growth performance for the skilled Northern city along the entire path of international economic integration, leading to divergence in urban success in the North. Furthermore, this mechanism proposed by the model to account for spatial divergence in the North, that ties the relative success of skilled cities to their specialization in management and other activities that benefit from internationalization, is consistent with empirical evidence. In Appendix D I provide some suggestive evidence that initial specialization in management (and other activities that can be classified as "international commerce") is associated with economic success across US cities in recent decades.

Finally, I present the model's implications for the spatial distribution of workers by skill and the evolution of land prices across locations.

Proposition 4. *Along the path defined by unique stable equilibria, for any* $\tau^* < \tau \leq T_{max}$*, a reduction in* τ *is associated with skill divergence across cities and/or divergence in the price of land across cities in each country. Formally,* $\forall \tau \leq T_{max}$*:*

$$\frac{\partial}{\partial \tau}\left(\frac{H_{S2}}{L_{S2}} - \frac{H_{S1}}{L_{S1}}\right) \leq 0 \qquad \frac{\partial}{\partial \tau}\left(\frac{r_{S2}}{r_{S1}}\right) \leq 0 \tag{14}$$

$$\frac{\partial}{\partial \tau}\left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right) \leq 0 \qquad \frac{\partial}{\partial \tau}\left(\frac{r_{N2}}{r_{N1}}\right) \leq 0 \tag{15}$$

with at least one inequality in each pair (14) *or* (15) *above being strict.*

As communication costs decline, the spatial economy goes through a number of stages, which the next section discusses in greater detail. Within each country, two configurations are typical. The less skilled city may fully specialize in the country's less skill intensive sector (u in the South and s in the North), while the more skilled city hosts both the same sector and the more skill intensive one (s in the South and M in the North). Otherwise, both cities in each country may fully specialize in different sectors (u for $S1$, s for $S2$ and $N1$, M for $N2$).

When the first type of configuration prevails, a reduction in communication costs increases the skill share differential between cities within countries but keeps the land price differential unchanged. This is because falling communication costs make the most skilled sector in each country grow. As a result, some of the less skill intensive activities in the country's skilled city relocate, leaving the advanced location with a greater exposure to the most skill intensive sector, and thus with a higher skill share. On the other hand, in this type of configuration, small reductions in communication costs have no impact on the sectoral composition of the lagging city, and thus leave that location's skill share unchanged. Increasing skill shares in advanced locations coupled with stagnating ones in lagging cities lead to skill polarization across space. Moreover, when the skilled city has a mixed industrial composition, the relative land rents between urban locations within the country are fixed by the less skilled sector, which is on the locational margin between the two cities, and are thus invariant to small changes in communication costs.

On the other hand, when both cities within a country are fully specialized, growth in the more skilled sector as communication technologies improve only translates into relative growth of the more skilled city, as the lagging cities never become competitive in their respective country's most skilled activity (this is guaranteed by Assumptions 3 and 4). As the relative weight of the skilled city in a country's value added grows and no further activity migrates out of the skilled city, this advanced location will experience congestion and an increase in real estate prices relative to the backward city.

4 A History of the Location of Economic Activity

In this section I complement the general results of the previous section with a detailed, stage by stage analysis of the evolution of the spatial economy in a world of improving communications. I first focus on the past and discuss how the model explains the recent shifts in global economic geography. I then turn to the future and present the model's predictions regarding the future impact of continuing globalization.

To provide a parsimonious characterization of the predictions of the model and avoid the proliferation of sub-cases, in this section I impose an additional parameter restriction. This is a technical "timing" assumption that fixes the sequencing of the full specialization moments of the two countries' advanced cities along the path of international economic integration. I describe this restriction in greater detail below:

Assumption 6 - Timing of Full Specialization - The expenditure share of skilled manufacturing (s) is sufficiently large relative to that of unskilled manufacturing (i.e. θ is sufficiently small) such that the skilled Southern city fully specializes in skilled manufacturing "before "(i.e. at higher levels of communication costs) the skilled Northern city fully specializes in management.

As globalization proceeds, the skilled city of the South tends to capture market share in skilled manufacturing and shed market share in unskilled manufacturing. Equally, in the North, the skilled city gradually loses market share in skilled manufacturing and becomes increasingly specialized in management. Assumption 6 ensures that as this process unfolds, full specialization (in skilled manufacturing) takes place first in the South's advanced city. This assumption has modest implications for the qualitative predictions of the model and is made for ease of exposition[23].

4.1 The Globalization of Skilled Manufacturing

With this additional restriction in place[24], I proceed to interpret the recent shifts in economic geography through the lens of the model. I begin my account from the spatial configuration outlined in Proposition 1, which arguably describes the state of affairs in the middle of the twentieth century: relatively concentrated economic activity across countries; stark differences between the internal economic geographies of countries, with industrialized nations featuring high levels of urbanization and notable concentration of economic activity while the economic geography of developing countries remains more dispersed; relatively low levels of geographical segregation of the skilled in both North and South coupled with small within country disparities in the price of land.

The first stage of globalization begins when international communication costs fall below the threshold at which skill-intensive manufacturing becomes economical to undertake in the South[25]. The implications of this

[23] For lower values of the expenditure share of s, $N2$ would attain specialization before $S2$. As a result, in the second stage of globalization the model would predict skill divergence across Southern cities and land price divergence across Northern cities

[24] Aside from the additional parametric restriction outlined in Assumption 6, the analysis in this section also maintains the more restrictive version of Assumption 5 (denoted Assumption 5b). See Appendix A for formal statements of these restrictions.

[25] The re-location of skilled manufacturing from North to South could occur in two ways that are equivalent from the perspective of the model: the entry of domestic Southern firms into new activities; or offshoring by Northern firms. The latter mechanism is easier to document, as it associated with an observable trail of FDI: FDI flows to a greater extent to the more skilled regions of developing countries (Nunnenkamp 2002), affiliates of foreign entities are more skill intensive than domestic firms (Feenstra and Hanson 1997), and FDI flows are self-perpetuating (Head, Ries and Svenson 1995, O'Huallachain and Reid 1997, Smith and Florida 1994). Moreover, FDI flows seem to have a significant impact on local economic success (Wei 1999). Some evidence also

first stage of globalization for the configuration of the spatial economy are outlined below:

Stage 1: The Globalization of Skilled Manufacturing Along the interval of communication costs given by $T_{spec1} < \tau \leq T_{max}$ the equilibrium configuration of economic activity across space is depicted in Figure 4 Skilled manufacturing (s) takes place in locations $\{S2, N1, N2\}$, unskilled manufacturing (u) in both Southern cities while management services (M) in $N2$ [26]. Along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities ($S2$ and $N2$) in both countries, and skill polarization across space within countries.

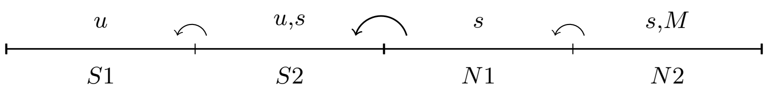

Figure 4: First Stage of Globalization

As the first stage of globalization unfolds, location $S2$ leverages its high infrastructure endowment to become competitive in skilled manufacturing and take on the role of the South's skilled city. As a result, city $S2$ gains market share in skilled manufacturing while unskilled manufacturing is crowded out and aids the growth of city $S1$. The higher employment density of skilled manufacturing guarantees that population growth in city $S2$ is faster than in $S1$, leading to the "take-off"of this location relative to the rest of the country. Moreover, the shift of skilled manufacturing to the South is still limited enough that the relatively unskilled activities of each country (u in the South, s in the North) remain the main consumers of urban land and the main drivers of urban land prices. As a result, land rental rate differentials display little change within countries. The margin of adjustment to sectoral reallocation across space is the industrial composition and skill shares of cities, as highlighted in proposition 4. Consequently, in this early stage of globalization, the model predicts skill polarization across cities within countries.

While Proposition 3 establishes the *relative* performance of Northern cities, the evolution of the *absolute* size of Northern cities is ambiguous during this stage of globalization. Northern locations are subject to two competing forces. On the one hand, their weight in the overall value added of the urban sector declines as communication costs fall. This tends to make Northern cities smaller. On the other hand, the overall size of the urban sector increases, bringing about an increase in overall urbanization. In turn, this increase in the size of the urban sector benefits all cities, including those of the North. Northern cities may therefore decline in absolute size in the early periods of globalization. This is consistent with the experience of American cities during the 1970s, which largely experienced population declines irrespective of their skill endowments (Glaeser and Ponzetto 2010).

The predictions concerning the first stage of globalization outlined above are broadly consistent with empirical observation. Reductions in communications costs have coincided with the increasing spatial separation

supports the former mechanism: easier access to foreign intermediates and capital goods increases the productivity of domestic firms (Amiti and Konings 2007; Eaton and Kortum 2001) and allows them to increase the scope of their production (Goldberg, Khandelwal, Pavnick and Topalova 2009, 2010; Feng, Li and Swenson 2013)

[26] For the formal expression that gives the threshold T_{spec1} check the discussion under the heading Result 7 in Appendix B.

of management and the production facilities of firms (Kim 1999; Duranton and Puga 2005; Henderson and Ono 2008). They have also contributed to the rise of multinational firms, which can be considered extreme cases of separation between management and production (Markusen 1995). Furthermore, international economic integration has been accompanied by developing countries diversifying their economies into increasingly complex and skill intensive activities. The literature on trade integration and offshoring has related this development with increased skill premia in the South (Csillag and Koren 2011; Mazumdar and Quispe-Agnoli 2002), the displacement of unskilled workers in the North, and the increased complexity of the tasks performed by workers in the North (Ottaviano, Peri and Wright 2013; Lu and Ng 2012). Moreover, a series of recent studies (Schott 2007; Rodrik 2006; Hausmann, Hwang and Rodrik 2007) have built measures of export sophistication across countries and found a trend of rapidly expanding export sophistication among developing nations.

Finally, as the model predicts, recent globalization has had an uneven impact within countries. A growing literature has analyzed the impact of trade integration, and in particular import competition, on local economies within countries and has found asymmetric effects (Autor, Dorn and Hanson 2013; Topalova 2007, 2010; Dauth, Findeisen and Suedekum 2014; Costa, Garred and Pessoa 2015). Moreover, in developing countries, the economic diversification brought about by globalization has also proceeded unevenly. Jarreau and Poncet (2012) build measures of export sophistication at the sub-national level in China and document not only that China's export sophistication has been growing over time, but also that substantial regional disparities in export sophistication have emerged and persist within China. They also find that regions that displayed greater export sophistication have enjoyed more rapid economic growth.

4.2 Full Specialization of the South's Advanced City

As communication costs continue to decline and a larger fraction of skilled manufacturing shifts to the South, unskilled manufacturing is gradually crowded out from the leading Southern location $S2$. Similarly, in the North, the increased competitiveness of the South in skilled manufacturing coupled with continued growth in the management services sector leads to the gradual crowding out of skilled manufacturing from the North's skilled city $N2$. As this process unfolds, at some point the skilled city of either the South or the North may become completely specialized in their country's more skill intensive activity. Under Assumption 6 this occurs first in the South, launching the second stage of globalization:

Stage 2: Full Specialization of the South's Advanced City Along the interval of communication costs given by $T_{spec2} < \tau \leq T_{spec1}$ the spatial configuration of economic activity is depicted in Figure 5 [27]. Any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, skill polarization across Northern cities and divergence in real estate prices across Southern cities, with skilled cities favored.

During the second stage of globalization, in the North, the margin of adjustment to the international relocation of skilled manufacturing is still the industrial structure of cities (and implicitly their skill share).

[27] For the formal expression that gives the threshold T_{spec2} check the discussion under the heading Result 8 in Appendix B.

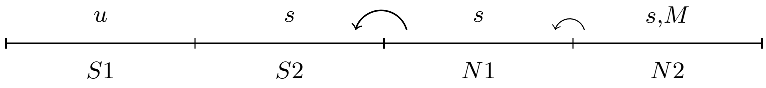

Figure 5: Second stage of globalization

However, in the South, this margin of adjustment is exhausted and any further spatial reallocation is reflected in the relative land prices of the two Southern cities. Thus, skill polarization across space continues in the North, while divergence in land prices across cities is observed in the South.

This stage of globalization corresponds to the acceleration in growth experienced by manufacturing hubs in several developing countries, particularly in South East Asia, starting from the 1980s. As the disadvantage represented by high international communication costs is gradually eroded, developing world cities with access to good infrastructure and foreign markets are increasingly able to leverage their large pools of cheap labor to capture market share in advanced manufacturing. As these locations become fully specialized in skilled manufacturing, their continued attractiveness as production hubs puts upward pressure on rental rates for land. As a result, this stage of globalization is characterized by the continued divergence of leading Southern locations relative to their countries, but this time reflected both in faster population growth and in rapid real estate price appreciation.

4.3 A Pure Management City in the North

If the wage gap between the two countries is wide enough, continued improvements in communication technologies usher in a new stage of globalization with a fully specialized skilled city also in the North. As the spatial economy enters this third stage of globalization, another landmark threshold is reached - the threshold of communication costs at which the ambiguity surrounding the evolution of the *absolute* size of the skilled Northern city is eliminated. This is established in the following proposition:

Proposition 5. *Along the path defined by unique stable equilibria and for a large enough differential in labor costs between North and South, (i.e.* $\frac{\xi_{1N}}{\xi_{1S}}$ *large enough), there exists a threshold* $\bar{T}$*, with* $1 < \bar{T} < T_{max}$ *such that for every* $\tau < \bar{T}$*, any reduction in* τ *is associated with growth in the absolute size of the North's skilled city* $N2$*.*

This result can be most easily understood in conjunction with the characterization of the third stage of globalization:

Stage 3: A Pure Management City in the North Along the interval of communication costs given by $T_{ovt} < \tau < T_{spec2}$ the spatial configuration of economic activity is depicted in Figure 6 [28]. Along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, divergence in real estate prices across cities in both North and South, with relatively skilled cities favored.

During the third phase of globalization the unskilled city of the North is the only location that remains vul-

[28] The threshold T_{ovt} is defined formally in Result 9 in Appendix B.

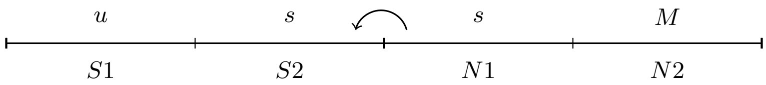

Figure 6: Third stage of globalization

nerable to increased competition from the South. As a consequence, it experiences continued relative declines in population and property prices. Improvements in communication gradually erode the productive advantage enjoyed by the unskilled Northern city relative to the advanced Southern location, and cause the market share in skilled manufacturing of the latter to keep increasing. Moreover, the interval of communication costs that characterizes the third stage of globalization contains a threshold $\tau^{CA} = \left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha}{1-\alpha}}$ at which city $S2$'s access to cheap Southern labor becomes more valuable than location $N1$'s frictionless access to management. As a result, below this threshold land rental rates in the South's skilled city overtake those in the lagging Northern location $N1$.

For the skilled Northern location, the onset of the third stage of globalization means that any ambiguity concerning its *absolute* population and land price growth is eliminated. Up to this point, reductions in communication costs had led to two opposing forces that drove changes in the absolute size of the advanced Northern location: losses of market share in skilled manufacturing and employment growth in the management services sector. However, at communication costs below T_{spec2} the skilled city of the North becomes fully specialized in management and the first force is no longer operational. This in turn guarantees that the skilled city of the North grows in absolute terms during the third stage of globalization.

The main feature of the third stage of globalization is that the main margin of adjustment to continued improvements in communications is given, in both countries, by land prices. As communication costs fall, we observe divergence in the price of land across cities in both North and South. These developments highlight the role played by the complementarity between international integration and agglomeration. While the relative prices of land in both countries' lagging cities decline sharply and serve as a force encouraging the dispersion of economic activity in each country, globalization also raises the value of the unique assets of each country's advanced city (infrastructure in the South, localization economies in the North). This latter force dominates and sustains an increasingly uneven economic geography in both North and South.

My discussion of the first three stages of globalization reveals that the model can also account for some of the finer details of the growth experience of cities in the US and other developed countries. In particular, it can explain the non-monotonic evolution of cities in many developed countries over the last few decades (Glaeser and Ponzetto 2010). Around 1970, most US cities, irrespective of their skill endowments, experienced population declines. By the 1990s skilled cities such as Boston and New York saw sustained economic and demographic recoveries. In contrast, cities such as Detroit or Buffalo, with unfavorable skill endowments and industrial specializations, continued to experience sluggish growth and even decline. This pattern of initial urban decline followed by a differential recovery favoring skilled cities corresponds to the transition between the second and third stages of globalization in my model.

4.4 The Future: Urban Overtaking

If the North-South wage gap is sufficiently wide, the continued fall of international communication costs opens up a novel possibility, that of urban overtaking along global value chains. The loss of skilled manufacturing in city $N1$ eventually drives its (relative) rental rates for land sufficiently low such that this location becomes competitive in unskilled manufacturing (which is relatively land intensive). The skilled city of the South thus acquires a more skill intensive industrial structure than the unskilled city of the North, and launches a new stage of globalization.

Proposition 6. *Along the path defined by stable equilibria, and for a large enough differential in labor costs between North and South, there exists a threshold T_{ovt}, with $1 < T_{ovt} < T_{max}$ such that if τ falls below T_{ovt} the skilled city of the South overtakes the unskilled city of the North along the global supply chain (i.e. $S2$ has a more skill intensive industrial structure than $N1$).*

Stage 4: Urban Overtaking Figure 7 depicts the spatial configuration of economic activity when communication costs are in the interval $\tau^* < \tau < T_{ovt}$[29]. During this stage of globalization, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, divergence in real estate prices across cities within countries, the de-skilling of city $N1$ and skill polarization across Northern cities.

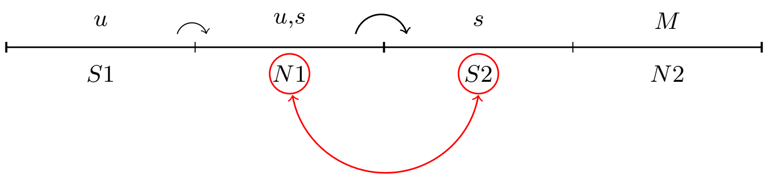

Figure 7: Fourth stage of globalization - urban overtaking

As urban overtaking unfolds, the Northern backward city experiences a trend of de-skilling because it loses jobs in skilled manufacturing and adds jobs in unskilled production. It also continues its relative decline in terms of population and real estate prices. This process of de-skilling in city $N1$ restores the trend of skill polarization across Northern cities. Urban overtaking also reinforces the divergent paths of Southern cities. As the unskilled Southern location $S1$ begins to lose market share in unskilled manufacturing to Northern city $N1$, the skilled Southern city continues to capture market share in skilled manufacturing. As a result, changes in absolute population for city $S1$ become ambiguous while city $S2$ continues to grow both in absolute terms and relative to $S1$.

While the developments described above are still far from becoming widespread trends, some evidence indicates that urban overtaking is already relevant for the most successful developing world cities. An analysis of real estate markets reveals that in 2002 lagging US metropolises such as Detroit and leading developing world cities such as Beijing displayed comparable rental rates for prime office space[30]. By 2013 a large gap in the

[29] For the formal expression that gives the threshold τ^* see Result 10 in Appendix B.

[30] As in my model land only features on the production side, office space rents are probably conceptually closest to the notion of rental rates for land in my model.

price of renting property had appeared between the two cities. Office rents in the Chinese capital rose rapidly not only to surpass those in Detroit but also rival rents in leading developed-world cities such as New York and London, while office rents in Detroit declined as the city suffered from the relocation of the automotive industry. This is all the more remarkable given the impressive supply response of the Beijing office market in the same period. Additional evidence consistent with urban overtaking is provided by Berry and Glaeser (2005), who find declines in the skill shares (i.e. deskilling) of a small number of US cities during the 1990s.

Beyond city outcomes, urban overtaking allows my model explain several additional phenomena. One is that of "reshoring", which has seen firms in developed countries bring some activities that had been offshored to developing countries back to their home markets. In an expanded version of my model, this development can be interpreted as follows. In a first wave of globalization, prohibitive cross-country transportation costs for goods and services are gradually eliminated while communication costs remain high. As a result, the North loses its unskilled manufacturing sector while the South loses its (small) management sector and skilled production sector. This leads to the configuration of economic geography similar described at the start of my analysis (in Proposition 1), before the onset of second wave (communication induced) globalization. As the first wave of globalization is exhausted and the second wave of globalization begins, the configuration of the spatial economy goes trough the stages $1-3$ described above, and finally enters stage 4, which sees unskilled manufacturing return to the North to take advantage of cheap land. This generates a pattern of spatial reallocation that may be described as reshoring.

The model can also account for two additional recent developments in rich country labor markets: the slowdown in educational attainment growth and labor market polarization. Along the overtaking stage of second wave globalization, the growth sectors in the North are unskilled manufacturing and management services, while skilled manufacturing is on the retreat. This can lead to a pattern of labor demand consistent with labor polarization (i.e. jobs are created in the most and the least skill intensive sectors, but not in middle-skill occupations) and to a slower growth in skill demand in the North.

Stage 5: Balanced Growth Finally, below τ^* (i.e. for $1 < \tau < \tau^*$), communication costs no longer impose a major impediment to the delivery of management services. As a result, worldwide economic geography is determined by unconstrained comparative advantage. This leads to the onset of Stage 5 of globalization, when the configuration of the spatial economy is given by cities $S1$ and $N1$ specializing in unskilled manufacturing, city $S2$ in skilled manufacturing and city $N2$ in the management function. During this stage of globalization, reductions in communication costs do not generate further spatial reallocation of activity across cities, which means that divergence in skill shares and land prices across cities ceases. However, urbanization continues and communication improvements are associated with proportionate growth in all cities.

5 Conclusion

The past fifty years have seen remarkable changes in worldwide economic geography. While urbanization has proceeded apace, the experiences of individual cities have recorded a wide array of urban successes and failures.

This variety in urban performance has been particularly noted in developed countries, where old industrial cities such as Detroit or Newcastle seem caught in perpetual decline, while other areas such as New York or London have been successful by reinventing themselves as centers of skill-intensive services. Urban growth hasn't been even in developing nations either, as skilled cities such as Bangalore and Shenzen have been particularly successful in exploiting the opportunities offered by globalization and have grown rapidly.

In this paper I suggest that these developments share the same cause: the spatial re-arrangement of global value chains resulting from deepening international economic integration. The reduction of (cross-country) spatial frictions, which I interpret as the result of improved communication, allows increasingly skill-intensive stages of global value chains, which require substantial managerial oversight, to be carried out in remote locations, often in developing countries. This leads to improved economic conditions in these countries and to structural change that draws people from hinterlands to cities. Moreover, the more advanced locations of these poorer nations benefit disproportionately from the reconfiguration of global value chains. This is because they can leverage their superior infrastructure to increasingly specialize in more complex activities that can now be competitively undertaken in the South. In the North, locations that host the activities that face enhanced competition from developing countries as a result of globalization experience economic stagnation or even decline. Meanwhile, leading cities of developed countries thrive. This is because they can leverage their unassailable advantage at delivering the most skill-intensive services by selling to a larger and more integrated world economy.

My theory can also be employed to cast an eye at the future of cities. Future improvements in communication technologies will likely continue to hurt old manufacturing cities in the North, while boosting management and innovation hubs. They will also benefit most Southern urban areas, with a particularly strong effect on locations that offer conditions appropriate for skilled production. Certainly then, there is every reason to think that discrepancies in productivity and wealth across cities within countries will continue and even widen further.

Finally, this paper highlights that beyond the common challenges faced by all urban areas, cities also face particular challenges that relate to their position along global supply chains. For manufacturing cities in industrialized countries the main challenge is to upgrade to more skill intensive activities and thus mitigate the impact of foreign competition. For the leading locations of the South the challenge is to continue to capture more of the skill intensive stages of global production and perhaps eventually compete for the most advanced managerial and creative activities with the innovation hubs of industrialized countries. Naturally, the challenge faced by the advanced locations of industrialized nations lies in maintaining their notable productive advantage in these high skill and high value added activities. All in all, recent trends seem to point towards a world in which the parameters of the "global race" often mentioned by politicians involve greater competition between the ever more similar managerial and skilled production hubs of developed and developing nations, with countries' economic performance increasingly determined by the performance of their urban "national champions".

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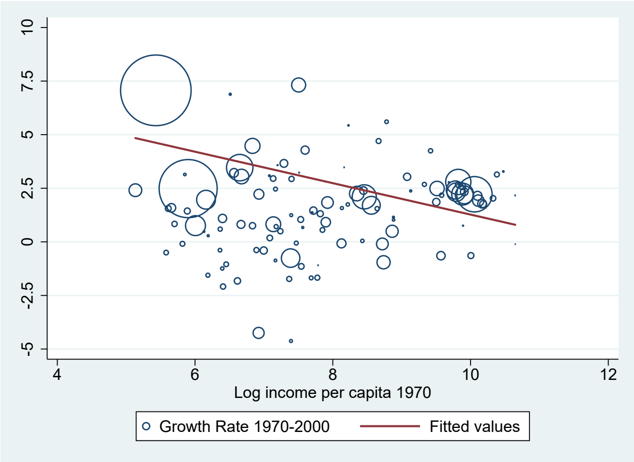
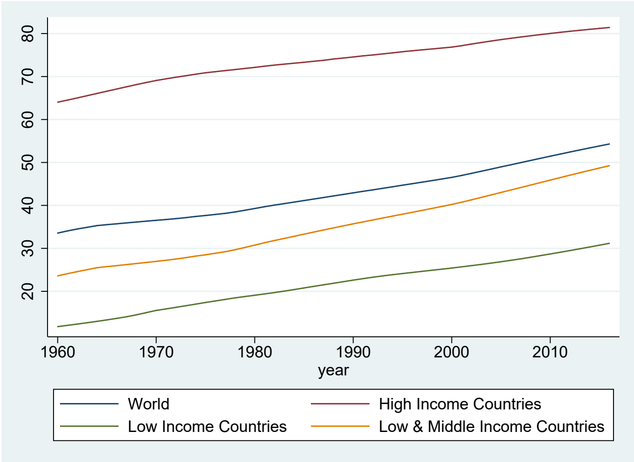
Figures



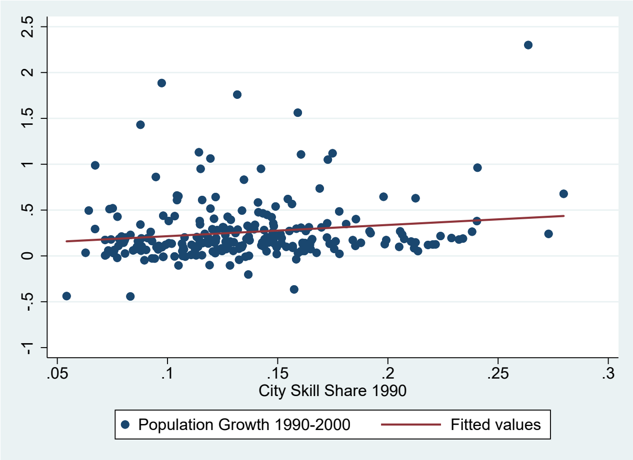
(a) Growth 1970-2000 Versus Initial Income (Population Weighted)



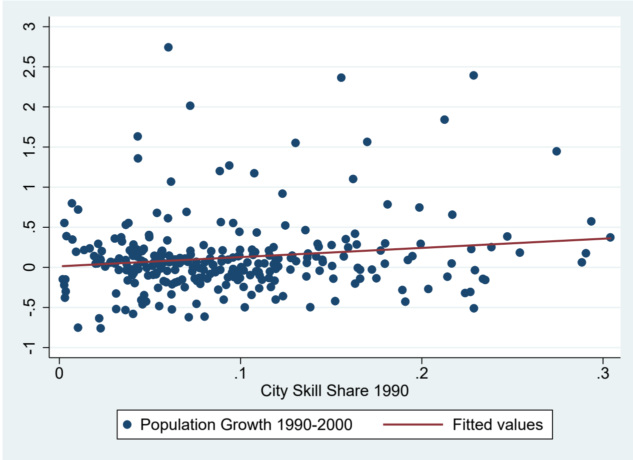
(b) Urbanization 1960-2016

Figure 1: Cross Country Convergence - Income and Urbanization

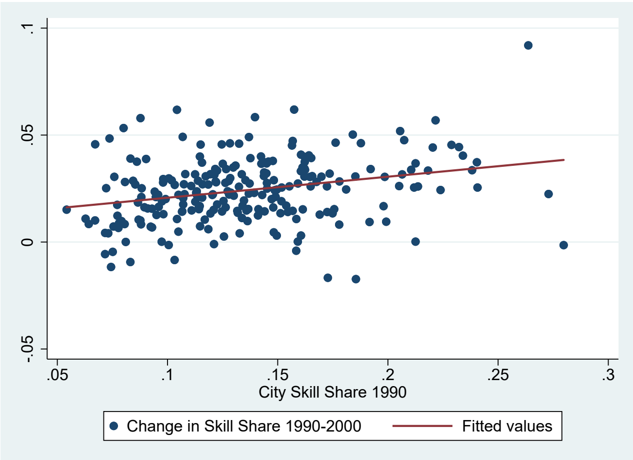
Notes: Pane a of the figure shows the population weighted relationship between initial income and income growth over the period 1970 to 2000 for a panel of 112 countries for which data is available. Income levels are measured as GDP per capita in constant 2010 dollars. Income data is obtained from the World Bank's World Development Indicators. Population data is obtained from the UN's World Population Prospects. Pane b of the figure shows the evolution of urbanization rates over time (1960-2016), for the world as a whole and for groups of countries defined by income (the country classification by income level is based on 2012 GNI per capita from the World Bank, while the income thresholds for allocation into groups are those used by the World Bank). The source of the urbanization data is the United Nation Population Division's World Urbanization Prospects.



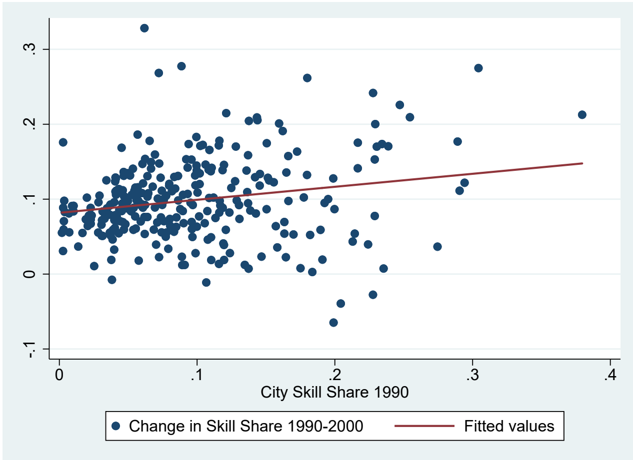
(a) Skills and City Growth - US



(b) Skills and City Growth - China



(c) Skill Divergence Across Cities - US



(d) Skill Divergence Across Cities - China

Figure 2: Widening Spatial Disparities Within Countries and Human Capital

Notes: Panes a and b of the figure show the relationship between initial skill shares and subsequent urban growth across US and Chinese cities respectively. The period covered by the data used in both panes a and b is 1990 to 2000. Panes c and d of the figure show the relationship between initial skill shares and changes in the skill shares for the period 1990 to 2000 across US and Chinese cities respectively. For the US, skill shares are defined as the share of each city's population that holds a bachelor degree at the relevant point in time. For China, skill shares are defined as the share of each city's population educated to "senior high school" level or higher at the relevant point in time. Data for the US (used in panes a and c) is obtained from the 5% samples of the 1990 and 2000 US Censuses available via IPUMS. Data for China is obtained from county level tabulations of the 1990 and 2000 Chinese Censuses. Our baseline samples contain 239 metropolitan areas for the US and 238 urban areas for China. For the purposes of graphical representation, in Pane b urban growth outliers in the case of China were eliminated without affecting the statistical relationship between skills and urban growth.

NOT FOR PUBLICATION

Appendix A: Key Assumptions

In this section I provide a rigorous formulation of the parametric restrictions I refer to in section 3.3.

Preliminaries and Clarifications

I begin by showing that, irrespective of the other parameters of a model, a sufficiently large γ can ensure that the traditional commodity is produced in both countries in equilibrium.

Result 1 For any set of parameters $\langle \alpha, \beta, \mu, \mu', \xi_{1N}, \xi_{1S}, \theta, \epsilon, L_S, L_N \rangle$ and for any localization economies function $\phi(.)$ there exists a threshold value $\underline{\gamma}$ such that for any $\gamma > \underline{\gamma}$ it must be the case that any equilibrium features production of the traditional commodity in both countries.

Proof: From the optimization problem of consumers, the relative expenditures on the two goods (traditional and urban) are given by (Y_i denotes expenditures on good i):

$$\frac{Y_2}{Y_1} = \left(\frac{1-\gamma}{\gamma}\right)^{\epsilon} \left[\frac{p_1}{p_2}\right]^{\epsilon-1} \tag{16}$$

Applying the implicit function theorem to this equation it is straightforward to show that:

$$\frac{\mathrm{d}}{\mathrm{d}\gamma}\left(\frac{Y_2}{Y_1}\right) < 0 \tag{17}$$

Furthermore, it is also the case that:

$$\lim_{\gamma \to 1}\left(\frac{Y_2}{Y_1}\right) = 0 \tag{18}$$

The latter equation implies that for any $T > 0$ there exists a γ such that

$$\left[\frac{Y_2(\gamma)}{Y_1(\gamma)}\right] < T \tag{19}$$

But then there implies that there exists a γ^* such that:

$$\left[\frac{Y_2(\gamma^*)}{Y_1(\gamma^*)}\right] < \frac{1}{\beta\theta + (1-\theta)[\alpha\mu + \beta(1-\mu)] + \mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]} \times \max\left\{\frac{\xi_{1S}L_S}{\xi_{1N}L_N}; \frac{\xi_{1N}L_N}{\xi_{1S}L_S}\right\} \tag{20}$$

For such a γ^* it can be shown that any equilibrium will feature traditional production in both countries. This is because, according to the equation above, such a γ induces equilibrium expenditure shares that are incompatible with the traditional good being produced in a single country. With relative expenditure shares between the traditional and the urban good given by the equation above, the concentration of the traditional sector in any one of the countries would lead to wages in that country to be pushed to such elevated levels that at least a fraction of that nations traditional good producers would prefer to deviate to the other country. Also, the same reasoning implies that for any $\gamma > \gamma^*$ there cannot be an equilibrium in which the entire traditional sector is hosted in only one country.

Finally, Result 1 is established by denoting $\underline{\gamma}$ to be the infimum of the set of γ^* above, that have the property that the economy given by

$$\langle \alpha, \beta, \mu, \mu', \xi_{1N}, \xi_{1S}, \theta, \epsilon, L_S, L_N, \gamma^* \rangle$$

and function $\phi(.)$ does not allow for an equilibrium in which the traditional commodity is produced in only one country for any $\tau \geq 1$.

Formal Statements of Parametric Restrictions

Assumption 1 The North is more productive in the traditional sector and the traditional sector is sufficiently large such that it is produced in both countries in any equilibrium. We thus assume that:

$$\xi_{1N} > \xi_{1S}$$
$$\gamma > \underline{\gamma}(\alpha, \beta, \mu, \mu', \xi_{1N}, \xi_{1S}, \theta, \epsilon, L_S, L_N)$$

Assumption 2 The production of management is infeasible in the South. We thus assume that:

$$\xi_{MS} = 0$$

Assumption 3 I require that localization economies are strong enough to generate clustering of the management sector in only one (Northern) city in any stable equilibrium. The function $\phi(.)$ governing the strength of localization economies in the management services sector is thus assumed to have the following properties:

Property 1: $\phi(0) > 0$

Property 2: $\phi'(x) > 0$ for all $x \in [0, 1]$

Property 3:

$$\frac{\phi(1)}{\phi(0)} > \left\{ \mu(1-\alpha)(1-\mu')\frac{1-\theta}{\theta}\left[1 + \left(\frac{\xi_{1N}}{A\xi_{1S}}\right)^{\frac{\beta}{1-\beta}}\right]\right\}^{(1-\beta)(1-\mu')}$$

Property 4: $\phi'(x) > \phi(1/2)\left(\frac{x}{1-x}\right)^{(1-\beta)(1-\mu)}$ for any x in the interval

$$x \in \left[\frac{1}{2}, \underbrace{\frac{\mu(1-\alpha)(1-\mu')\left[1+\left(\frac{\xi_{1N}}{\xi_{1S}A}\right)^{\frac{\beta}{1-\beta}}\right]}{1+\mu(1-\alpha)(1-\mu')\left[1+\left(\frac{\xi_{1N}}{\xi_{1S}A}\right)^{\frac{\beta}{1-\beta}}\right]}}_{\overline{x}}\right]$$

Assumption 4 I assume that the role of infrastructure in skilled manufacturing (intermediate s) is sufficiently important that the lagging Southern location $S1$ can never undertake this activity in equilibrium. In particular, I assume that:

$$\rho > \max\left\{\frac{(1-\beta)(1-\mu)}{\alpha\mu}\frac{\ln\left\{\frac{1-\theta}{\theta}(1-\mu)\left[1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}\right]\right\}}{\ln A} - \frac{\beta(1-\mu)}{\alpha\mu}, \frac{\ln\frac{\xi_{1N}}{\xi_{1S}}}{\ln A}\right\}$$

Assumption 5 requires that the North-South wage gap is sufficiently large (i.e. ξ_{1N}/ξ_{1S} is sufficiently large) such that in the absence of communication costs some Southern locations have a comparative advantage in the completion of skilled manufacturing. In other words we assume that the presence of communication costs imposes a binding constraint on the production possibilities of the South. In our analysis we maintain two versions of this assumption (denoted Assumptions 5a and 5b) with one (Assumption 5b) being more restrictive. These restrictions are presented in greater detail below:

Assumption 5a A necessary condition for the South to be competitive in the production of skilled manufacturing (s) in the absence of communication costs. I require that the relative size (in terms of their expenditure shares) of the urban sectors obeys the relationship:

$$\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\beta}{1-\beta}} > \frac{2\frac{K_1}{1+K_1}}{[(1-\mu)+\mu(1-\alpha)(1-\mu')]}\frac{\theta}{1-\theta}$$

where $K_1 = A^{\frac{\beta}{1-\beta}}$

Assumption 5b A stricter version of Assumption 5a which I impose throughout my analysis in order to explore the full predictive possibilities of the model. I require that the labor cost differential between the two countries (reflected in their respective productivity in the traditional sector) is sufficiently large such that:

$$A^{\frac{\beta(1-\mu)}{\mu(1-\alpha)}}\left[\frac{\theta}{(1-\mu)(1-\theta)}\right]^{\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}}\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha}{1-\alpha}} \geq \left[1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}\right]^{\frac{(1-\mu)(1-\beta)}{\mu(1-\alpha)}}$$

By assuming a sufficiently large differential in labor costs between the two nations, I am able to illustrate the entire range of stages that the configuration of the (worldwide) spatial economy can go through as communications costs are gradually lowered. Starting from this benchmark analysis it is then straightforward to consider cases in which differentials in labor costs (and hence productivity in the traditional sector) are lower, as this will mean that the configuration of worldwide economic geography will only go through an ordered subset of the stages described in my analysis.

Assumption 6   A technical "timing"assumption. I assume that

$$\frac{1-\theta}{\theta} > \frac{2(1+K_1)}{[(1-\mu)+\mu(1-\alpha)(1-\mu')]} \times \left[\frac{\mu(1-\alpha)(1-\mu')}{(1-\mu)-\mu(1-\alpha)(1-\mu')} + \frac{K_1}{2(1+K_1)}\right]$$

The parametric assumption above merely affects the "timing" of the stages of specialization the world economy goes through as communication costs are gradually reduced. It has no bearing on the overall qualitative predictions of the model.

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Appendix B: Proofs

In what follows, I proceed to the proofs of the main results reported in the paper. Throughout my analysis I maintain Assumptions $1-6$ described above. For the purposes of this section and the rest of the Appendix, the notions of unskilled manufacturing and intermediate u, skilled manufacturing and intermediate s, and management (services) or intermediate M are used interchangeably.

Preliminaries: Solving the Model

I begin with the optimization problem of consumers. Given the CES utility function describing consumer preferences, the relative expenditures on the two goods (traditional and urban) are given by (Y_i denotes expenditures on good i):

$$\frac{Y_2}{Y_1} = \left(\frac{1-\gamma}{\gamma}\right)^{\epsilon}\left[\frac{p_1}{p_2}\right]^{\epsilon-1} \tag{21}$$

Furthermore, designating utility as the numeraire yields:

$$\gamma^{\epsilon}p_1^{1-\epsilon} + (1-\gamma)^{\epsilon}p_2^{1-\epsilon} = 1 \tag{22}$$

Moreover, given the perfectly competitive environment that prevails on the supply side of good markets, commodities are priced at the cost of production - see (7). In the case of the traditional good, this means that the equilibrium price exactly covers the compensation of unskilled workers, expressed per unit of output, at each cost minimizing location:

$$p_1 = \min_{c\in\{N,S\}}\left\{\frac{w_c^U}{\xi_{1c}}\right\}$$

where w_c^U denotes the unskilled wage rate in country c (note that free mobility within countries means that the unskilled wage is equalized across locations, both rural and urban, within countries). As Assumption 1 guarantees that the traditional good is produced in equilibrium in both N and S, the level of (unskilled) wages in the two countries is given by (9).

For the case of the urban good, optimization by perfectly competitive producers implies that its equilibrium price is

$$p_2 = \left(\frac{p_u}{\theta}\right)^{\theta}\left(\frac{p_s}{1-\theta}\right)^{1-\theta} \tag{23}$$

while the expenditures on the requisite stages of production or intermediates involved in production of the urban good are given by

$$Y_u = \theta Y_2 \qquad\qquad Y_s = (1-\theta)Y_2 \tag{24}$$

Moving to the analysis of the supply side of urban intermediates, perfect competition and costless transport across and within countries imply that these commodities are only produced at worldwide cost minimizing locations:

$$p_u = \min_{l \in \{S1, S2, N1, N2\}} c_l(u)$$
$$p_s = \min_{l \in \{S1, S2, N1, N2\}} c_l(s)$$

where, as before, $c_l(i)$ represents the minimum cost of production of intermediate i ($i \in \{u, s, M\}$) at location (city) l. In turn, optimization by profit maximizing intermediate producers implies that these cost functions are given by:

$$c_l(u) = \left(\frac{1}{A_l}\frac{w_l^U}{\beta}\right)^{\beta}\left(\frac{r_l}{1-\beta}\right)^{1-\beta}$$
$$c_l(s) = \left[\frac{1}{\mu}\left(\frac{1}{A_l^{\rho}}\frac{w_l^S}{\alpha}\right)^{\alpha}\left(\frac{p_l^M}{1-\alpha}\right)^{1-\alpha}\right]^{\mu}\left[\frac{1}{1-\mu}\left(\frac{1}{A_l}\frac{w_l^U}{\beta}\right)^{\beta}\left(\frac{r_l}{1-\beta}\right)^{1-\beta}\right]^{1-\mu}$$

where as previously established, w_l^U, w_l^S represent the unskilled and skilled wages at location (city) l while p_l^M denotes the price of management services at a location l. Note that wages for workers of a particular skill level are the same across locations within countries but differ across countries, as established in equation (9).

Concerning the management sector, Assumption 3 guarantees that equilibria in which the entire sector is clustered in one of the Northern locations exist and are stable. From the demand system of the model I can then derive a simple expression for the revenues of the management sector:

$$Y_M = \mu(1-\alpha)(1-\theta)Y_2$$

The absence of communication costs in the North means that there is a unique price for management services across locations within this country. From the supply side of the model I can derive expressions for the price of management at various locations:

$$p_M^N = \frac{1}{\phi(1)}\left(\frac{1}{A^{\rho}}\frac{w_N^S}{\mu'}\right)^{\mu'}\left[\frac{1}{1-\mu'}\left(\frac{1}{A}\frac{w_N^U}{\beta}\right)^{\beta}\left(\frac{r_{N2}}{1-\beta}\right)^{1-\beta}\right]^{1-\mu'} \tag{25}$$
$$p_M^S = \tau p_M^N$$

where p_M^S denotes the price of management services in the South (note that Southern locations are subject to symmetric communication costs when sourcing the management services from the North) while the term $1/\phi(1)$ reflects the fact that the management is produced with maximal productivity in equilibria featuring complete agglomeration of the management sector in only one city ($N2$).

Finally, I focus attention on primary factor markets. Exploiting the demand side of labor markets I obtain the following expressions that govern the total remuneration of skilled and unskilled workers across locations and sectors:

$$
\begin{aligned}
w_l^U L_u^l &= \beta Y_u^l \\
w_l^U L_s^l &= \beta(1-\mu) Y_s^l \\
w_l^S H_s^l &= \alpha \mu Y_s^l \\
w_N^S H_M^{N2} &= \mu' Y_M \\
w_N^U L_M^{N2} &= \beta(1-\mu') Y_M
\end{aligned}
$$

with $l \in \{S1, S2, N1, N2\}$:

$$\sum_{l \in \{S1,S2,N1,N2\}} \sum_{i \in \{u,s\}} Y_i^l = Y_2$$

where, as before, Y_2 denotes worldwide expenditure on the urban good.

On the supply side of labor markets, the assumptions of perfect within country mobility of workers, their frictionless mobility across sectors, as well as the access of all workers to an identical education technology ensure that in any equilibrium wages adjust to make workers indifferent across occupations and locations within their country of residence:

$$w_{S1}^U = w_{S2}^U = w_S^U = \xi_{1S} p_1 \qquad w_{S1}^S = w_{S2}^S = w_S^S = \frac{w_S^U}{1-e} = \frac{\xi_{1S} p_1}{1-e} \tag{26}$$

$$w_{N1}^U = w_{N2}^U = w_N^U = \xi_{1N} p_1 \qquad w_{N1}^S = w_{N2}^S = w_N^S = \frac{w_N^U}{1-e} = \frac{\xi_{1N} p_1}{1-e} \tag{27}$$

Relative wages across countries are fixed by their relative productivity in the traditional sector (Assumption 1) while skill premia in both countries are fixed by the exogenous educational technology. Land prices adjust such that the demand for land equates the inelastic land supply in each city $l \in \{N1, N2, S1, S2\}$ according to equation (11).

Finally, when characterizing the evolution of global economic geography, I am particularly interested in tracking how reductions in international communication costs affect cities' populations, skill shares and real estate prices, as well as overall (worldwide) urbanization. While real estate prices in equilibrium are pinned down by equation (11), the expressions for a city's equilibrium population and skill share are given by equations (14) and (15).

Proof of Proposition 1

I proceed by first proving a series of intermediary results.

Result 2 Under the assumptions above, in any equilibrium, $S1$ must be fully specialized in unskilled manufacturing (u).

The proof proceeds by contradiction. Let us assume that there is an equilibrium in which $S1$ houses some skilled manufacturing s (note that the production of M is assumed infeasible in the South). This means that:

$$c_{S1}(s) \leq c_{S2}(s)$$
$$c_{S1}(s) \leq c_{N1}(s)$$
$$c_{S1}(s) \leq c_{N2}(s)$$

given that we have, by Assumption 4 that

$$\rho > \frac{\ln \frac{\xi_{1N}}{\xi_{1S}}}{\ln A} \tag{28}$$

which ensures that the cost of the composite given in the first bracket of the cost function of s is always higher in $S1$ than in any Northern location, then it must be the case that:

$$\left[\left(\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S1}}{1-\beta}\right)^{1-\beta}\right] < \left[\left(\frac{1}{A}\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}\right] \tag{29}$$

$$\left[\left(\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S1}}{1-\beta}\right)^{1-\beta}\right] < \left[\left(\frac{1}{A}\frac{w_N}{\beta}\right)^{\beta}\left(\frac{r_{N1}}{1-\beta}\right)^{1-\beta}\right] \tag{30}$$

$$\left[\left(\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S1}}{1-\beta}\right)^{1-\beta}\right] < \left[\left(\frac{1}{A}\frac{w_N}{\beta}\right)^{\beta}\left(\frac{r_{N2}}{1-\beta}\right)^{1-\beta}\right] \tag{31}$$

But the expressions above are equivalent to:

$$c_{S1}(u) \leq c_{S2}(u)$$
$$c_{S1}(u) \leq c_{N1}(u)$$
$$c_{S1}(u) \leq c_{N2}(u)$$

Thus, in any such equilibrium, $S1$ must capture the entire intermediate u production activity. However, Assumption 4 also ensures that in configurations in which $S1$ amasses the entire u sector, then city $S2$ will be a strictly lower cost location for the production of intermediate s. Thus in such an equilibrium, s cannot be produced in location $S1$, leading to a contradiction and the completion of the proof.

Result 3 There cannot be an equilibrium featuring the partial agglomeration of the management sector.

Given that M can only be produced in the North, the only option for equilibria featuring partial agglomeration of the management sector would imply that one of the Northern cities captures a market share of $\frac{1}{2} < x < 1$ in the production of management services. Before the proof proceeds let us establish the following result:

Result 3.1 In any equilibrium involving the incomplete agglomeration of M, the city featuring a market share $x > \frac{1}{2}$ in management services must be fully specialized in the production of management services.

Given that we have incomplete specialization (assuming WLOG incomplete agglomeration in $N2$):

$$c_{N1}(M) = C_{N2}(M) \tag{32}$$

$$x_{N2} > \frac{1}{2} \Rightarrow \phi(x_{N2}) > \phi(x_{N1}) \tag{33}$$

It must then be the case that $r_{N1} < r_{N2}$ (the cities are identical in every respect and face the same labor costs). But from the point of view of all the other urban activities, cities $N1$ and $N2$ are symmetric so any firm specializing in any of the other activities would optimally choose to locate in $N1$ rather than $N2$. This establishes result 3.1.

Expanding and simplifying equation (32) above yields the following relation that must hold in any equilibrium featuring incomplete agglomeration:

$$\frac{\phi(x^*_{N2})}{\phi(1 - x^*_{N2})} = \left(\frac{r_{N2}}{r_{N1}}\right)^{(1-\beta)(1-\mu')} \tag{34}$$

But property 4 of the function characterizing the localization economies of the management sector ($\phi(.)$) guarantees that:

$$\frac{\phi(x_{N2})}{\phi(1 - x_{N2})} > \left(\frac{x_{N2}}{1 - x_{N2}}\right)^{(1-\beta)(1-\mu')} > \left(\frac{r_{N2}}{r_{N1}}\right)^{(1-\beta)(1-\mu')} \quad \forall x \in [\frac{1}{2}, \overline{x}] \tag{35}$$

where the last inequality follows from Result 3.1. But then it must be the case that $x^*_{N2} > \overline{x}$. We have that in the hypothesized equilibrium the following must hold:

$$\left(\frac{r_{N2}(x^*_{N2})}{r_{N1}(x^*_{N2})}\right)^{(1-\beta)(1-\mu')} = \frac{\phi(x^*_{N2})}{\phi(1 - x^*_{N2})} > \frac{\phi(\overline{x})}{\phi(1 - \overline{x})} > \left(\frac{\overline{x}}{1 - \overline{x}}\right)^{(1-\beta)(1-\mu')} \tag{36}$$

However the relationship above leads to a contradiction, as the real estate price differential between cities $N2$ and $N1$ required by equation (36) cannot be sustained in any equilibrium. In fact it can be shown that in any equilibrium the maximum differential in land prices between the two Northern city is bounded by the relationship:

$$\frac{r_{N2}}{r_{N1}} \leq \mu(1-\alpha)(1-\mu')\frac{1-\theta}{\theta}\left[1 + \left(\frac{\xi_{1N}}{\xi_{1S}A}\right)^{\frac{\beta}{1-\beta}}\right] \tag{37}$$

The contradiction established between the requirements of equations (36) and (37) above complete the proof of Result 3.

Following Result 3 I have established that any potential equilibrium involves either symmetric cities in the North (it is straightforward to show that equilibria with $x^*_{N2} = \frac{1}{2}$ always exist) or completely agglomerated configurations, in which the entire management sector is clustered in one Northern city. In the next result, I show that there can be only one equilibrium involving complete agglomeration when $\tau > T_{max}$.

Result 4 For sufficiently high communication costs

$$\tau > \underbrace{\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{\mu(1-\alpha)}} \left\{\frac{(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{2\frac{K_1}{1+K_1}\theta}\right\}^{\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}}}_{T_{max}} \tag{38}$$

there can only be an unique equilibrium (up to a permutation of city labels in the North) in which the management services sector is fully agglomerated in only one of the Northern cities. The features of this equilibrium are as described in Proposition 1.

Again, in order to prove the above result, I first need to establish a series of intermediate results. These are outlined below.

Result 4.1 For $\tau > T_{max}$, there cannot be an equilibrium in which activity u is produced in the North.

Proof: Let us assume that we can identify an equilibrium in which u is indeed produced in the North. This would imply that in such an equilibrium, a location Ni where $i \in \{1, 2\}$ is a cost minimizing location for the production of intermediate u yielding:

$$\left[\left(\frac{1}{A}\frac{w_N}{\beta}\right)^{\beta}\left(\frac{r_{Ni}}{1-\beta}\right)^{1-\beta}\right] \leq \left[\left(\frac{1}{A}\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S1}}{1-\beta}\right)^{1-\beta}\right] \tag{39}$$

$$\left[\left(\frac{1}{A}\frac{w_N}{\beta}\right)^{\beta}\left(\frac{r_{Ni}}{1-\beta}\right)^{1-\beta}\right] \leq \left[\left(\frac{1}{A}\frac{w_S}{\beta}\right)^{\beta}\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}\right] \tag{40}$$

But then given that $T_{max} > \left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha}{1-\alpha}}$ and given Assumption 4 this implies that:

$$c_{N1}(s) < c_{S1}(s) \tag{41}$$

$$c_{N1}(s) < c_{S2}(s) \tag{42}$$

which means that in the posited equilibrium, the South cannot be hosting production of any s. Hence this implies that in such an equilibrium, the South is fully specialized in activity u. But then, due to Assumption 5b it must be the case that the South captures the entire unskilled manufacturing (u) sector, which leads us to a contradiction with our assumption that there is an equilibrium for $\tau > T_{max}$ in which u is produced in the North, and thus concludes the proof.

Result 4.2 For $\tau > T_{max}$, there cannot exist an equilibrium featuring complete agglomeration of management in which s is produced in the South.

Result 1 and result 4.1 mean that there are only two possible configurations left for potential agglomerated equilibria. One features the South producing activity u and the North producing the entire outputs of urban sectors s and M, whereas the other possible configuration features the South capturing the entire activity u but also some market share in intermediate s, while the North retains the complementary market share in s

and has a monopoly position in the production of management services.

Let us assume that we have identified an equilibrium for $\tau > T_{max}$ such that s is produced in the South. Result 2 dictates that any such equilibrium features activity s being undertaken in the South's "advanced" city $S2$. This yields the following:

$$c_{S2}(s) \leq c_{N1}(s) \tag{43}$$

$$(r_{S1} + r_{S2})\overline{N} = (1-\beta)\theta Y_2 + x(1-\beta)(1-\mu)(1-\theta)Y_2 \tag{44}$$

where x above represents the South's market share in the skilled manufacturing (s) in the posited equilibrium. From result 2 and noting the infrastructure differential between cities $S1$ and $S2$ I can write:

$$r_{S2} \geq \underbrace{A^{\frac{\beta}{1-\beta}}}_{K_1} r_{S1} \tag{45}$$

Plugging equation (45) into (44) yields

$$(r_{S1} + r_{S2})\overline{N} = (1-\beta)\theta Y_2 + x(1-\beta)(1-\mu)(1-\theta)Y_2 \leq \left(\frac{r_{S2}}{K_1} + r_{S2}\right)\overline{N} \tag{46}$$

which can be rewritten:

$$r_{S2} \geq \frac{K_1}{1+K_1}\frac{(1-\beta)\theta Y_2 + x(1-\beta)(1-\mu)(1-\theta)Y_2}{\overline{N}} \tag{47}$$

On the other hand, in the posited equilibrium it must also be the case that:

$$(r_{N1} + r_{N2})\overline{N} = (1-x)(1-\beta)(1-\mu)(1-\theta)Y_2 + \mu(1-\alpha)(1-\mu')(1-\theta)Y_2 \tag{48}$$

Noting the (ex-ante) symmetric characteristics of Northern cities and restricting (without loss of generality) attention to configurations in which the complete agglomeration of management occurs in location $N2$ then I can write:

$$r_{N2} \geq r_{N1} \tag{49}$$

Combining the last two equations I obtain:

$$r_{N1} 2\overline{N} \leq (1-x)(1-\beta)(1-\mu)(1-\theta)Y_2 + \mu(1-\alpha)(1-\mu')(1-\theta)Y_2 \tag{50}$$

which can be rewritten as:

$$r_{N1} \leq \frac{(1-x)(1-\beta)(1-\mu)(1-\theta)Y_2 + \mu(1-\alpha)(1-\mu')(1-\theta)Y_2}{2\overline{N}} \tag{51}$$

Expanding and simplifying equation (43) yields:

$$r_{N1} \geq \left(\frac{\xi_{1S}}{\xi_{1N}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{(1-\beta)(1-\mu)}} \tau^{\frac{\mu(1-\alpha)}{(1-\beta)(1-\mu)}} r_{S2} \tag{52}$$

which can be rewritten:

$$\frac{r_{N1}}{r_{S2}} \geq \left(\frac{\xi_{1S}}{\xi_{1N}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{(1-\beta)(1-\mu)}} \tau^{\frac{\mu(1-\alpha)}{(1-\beta)(1-\mu)}} \tag{53}$$

Substituting $\tau > T_{max}$ into the equation above gives us:

$$\frac{r_{N1}}{r_{S2}} \geq \frac{(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{2\frac{K_1}{1+K_1}\theta} \tag{54}$$

On the other hand, dividing equations (51) and (47) yields:

$$\frac{r_{N1}}{r_{S2}} \leq \frac{(1-x)(1-\mu)(1-\theta)+\mu(1-\alpha)(1-\mu')(1-\theta)}{2\frac{K_1}{1+K_1}[\theta+x(1-\beta)(1-\mu)(1-\theta)]} \tag{55}$$

The incompatibility of the inequalities (54) and (55) means that I have reached a contradiction, which completes the proof of result 4.2.

In light of result 4.2 the only possibility that remains is an equilibrium configuration in which urban sector u locates exclusively in the South, while M and s locate exclusively in the North. It is straightforward to check that the configuration described by Proposition 1 is indeed an equilibrium: given that the South completely specializes in u, it is indeed the lowest cost location for intermediate u production; the North produces management services and the presence of large ($\tau > T_{max}$) communication costs for the international delivery of management makes production of s uneconomical in the South. The suggested configuration can also be shown to satisfy the requirements for locational equilibrium within countries. Finally, given that the configuration of the spatial economy outlined in Proposition 1 was reached via a process of elimination, it must be the case that this is indeed the only equilibrium featuring asymmetric Northern cities.

Result 5 Symmetric equilibria are never stable in the sense of Definition 2.

Under a symmetric equilibrium, half of the management sector is hosted by each of the Northern cities. This implies:

$$c_{N1}(M) = c_{N2}(M) \tag{56}$$

Expanding and simplifying the equation above:

$$\frac{1}{\phi(x)} r_{N2}(x)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} = \frac{1}{\phi(1-x)} r_{N1}(x)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} \tag{57}$$

which can be rewritten as

$$\frac{\phi(x)}{\phi(1-x)}|_{x=\frac{1}{2}} = \left(\frac{r_{N2}(x)}{r_{N1}(x)}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} \tag{58}$$

It can be shown that in any symmetric equilibrium it must be the case that:

$$\frac{\partial}{\partial x}\left(\frac{r_{N2}(x)}{r_{N1}(x)}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} \leq \frac{\partial}{\partial x}\left(\frac{x}{1-x}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} \tag{59}$$

i.e. the effect of a disturbance reflected in the partial derivative at the symmetric equilibrium is largest in a hypothetical scenario in which the North is completely specialized in management services. But property 4 of Assumption 3 guarantees that:

$$\frac{\partial}{\partial x}\left(\frac{\phi(x)}{\phi(1-x)}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} > \frac{\partial}{\partial x}\left(\frac{x}{1-x}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}} \geq \frac{\partial}{\partial x}\left(\frac{r_{N2}(x)}{r_{N1}(x)}\right)^{(1-\beta)(1-\mu)}|_{x=\frac{1}{2}}$$

Thus, a locational deviation by a small (but positive) mass of M producers from one of the symmetric Northern cities in such an equilibrium makes the recipient city **more** attractive for firms in the management services sector and less attractive to firms operating in the other urban sectors. This implies that symmetric equilibria are unstable in the sense of Definition 2.

Result 6 The asymmetric equilibrium configuration outlined in Proposition 1, which features complete clustering of management in city $N2$ (or city $N1$) is stable in the sense of Definition 2.

From the analysis of undertaken in the proof of Result 3, I know that moving a small mass Δx of firms from $N2$ to $N1$ (when the M cluster occurs at $N2$) will keep $N2$ as a strictly preferred location for the production of management services. Moreover, while the disturbance caused by the move of a small mass of management services firms from $N2$ to $N1$ would leave $N2$ more attractive than $N1$ in all urban sectors, the pull of the productive conditions remaining in $N2$ would be particularly strong for management services providers, so it can be shown that the asymmetric equilibrium outlined in Proposition 1 would be restored. Thus, this equilibrium is stable in the sense of Definition 2.

Finally, combining results 4, 5 and 6 above completes the proof of Proposition 1.

Comparative statics of threshold T_{max}

In this section I proceed to analyze the comparative statics of T_{max}, the threshold of communication costs above which skilled manufacturing is uneconomical to undertake in the South, with respect to the structural parameters of the model. These are summarized in Corrolary 1 below:

Corollary 1. *The threshold T_{max}, above which the production of the skilled manufacturing (s) in the South is uneconomical, has the following comparative static properties: $\partial T_{max}/\partial \xi_{1N} > 0, \partial T_{max}/\partial \xi_{1S} < 0, \partial T_{max}/\partial \theta < 0, \partial T_{max}/\partial \mu < 0, \partial T_{max}/\partial \mu' < 0, \partial T_{max}/\partial A < 0$.*

In line with economic intuition, increases in the relative price of Northern labor are found to cause increases of the threshold T_{max} ($\partial T_{max}/\partial \xi_{1N} > 0, \partial T_{max}/\partial \xi_{1S} < 0$). Raising the relative cost of labor in the North makes the South more attractive for the production of skilled manufacturing, and hence a higher communication cost is required to offset this added cost advantage of the South and maintain the entire skilled manufacturing sector in the North.

The third result of Corollary 1 ($\partial T_{max}/\partial \theta < 0$), which links the expenditure share of unskilled manufacturing with the threshold T_{max}, is also intuitive. An increase in the size of the unskilled manufacturing sector (and a converse decrease in the expenditure share of skilled manufacturing) implies that in a configuration of the spatial economy in which communication costs preclude the South from performing skilled manufacturing (s) and cause it to capture the entire unskilled manufacturing sector (u), the relative price of Southern land will be higher.[31] This makes the South relatively less attractive to skilled manufacturing firms, and thus a smaller communication cost is required to maintain the North's monopoly in s.

The interpretation of the fourth result ($\partial T_{max}/\partial \mu < 0$) is more involved, as an increase in the expenditure share μ of the "advanced" factors of production (skilled labor and management services) has three effects. Firstly, it increases the importance of management for the production of skilled manufactures, such that a lower communication friction can still be sufficient to substantially impair the South's competitiveness in producing this commodity. This effect can be expected to lead to a decline in T_{max}. Further, an increase in μ tends to weaken the dispersion force represented by fixed land supplies, as it both tends to reduce land prices and the importance of land in skilled production. Given that the presence of this dispersion force is the main factor preventing the concentration of economic activity in the North, a weakening of this mechanism also lowers the level of communication costs T_{max} required to preserve the North's decisive comparative advantage in skilled manufacturing. Finally, depending on the relative sizes of α and β, raising μ either makes skilled production more (if $\alpha > \beta$) or less (if $\alpha < \beta$) labor intensive. This effect then tends to either increase T_{max} if skilled manufacturing becomes more labor intensive (as in this case the South's cheap labor advantage is augmented) or to lower T_{max} if it becomes less labor intensive. The first two effects dominate the third irrespective of the direction of the latter, such that an increase in μ is always associated with a decline in the threshold T_{max}.

The effect of a rise in the land expenditure share of management, which is proportional to $1 - \mu'$, on the threshold T_{max} is straightforward: as the management sector only operates in the North, a rise in the expenditure of this sector on urban land has the effect of worsening congestion in the North, thus making this nation less attractive for skilled production. As a result, communication costs affecting the international delivery of management services need to rise to keep the entire skilled manufacturing sector in the North (i.e. $\partial T_{max}/\partial(1-\mu') > 0 \Rightarrow \partial T_{max}/\partial \mu' < 0$). Similarly, the implications of an increase in the infrastructure differential between the advanced locations ($S2$, $N1$, $N2$) and the backward one ($S1$) generated by a rise in A are clear. As the South hosts the infrastructure poor location, an increase in the productivity differential between this location and the rest is equivalent to a decline in the relative productive potential of the South overall. This in turn serves to lower the level of the communication costs required to discourage skilled production in the South.

[31] In a configuration like the one outlined in Proposition 1, the relative price of land in the two countries is given by the relative sizes of the sectors located in each country and their relative land intensities. Then ceteris paribus, an increase in the size of the unskilled manufacturing sector will increase land prices in the country housing it, namely the South. Assumption 5 ensures that whenever the South is uncompetitive in skilled manufacturing it can capture the entire unskilled manufacturing sector.

Proof of Propositions 2 to 6

It is straightforward to see that showing that the spatial economy goes through the configurations described as stages 1 to 5 of globalization is equivalent to proving the results presented in propositions $2-6$. In this section I prove a series of results that confirm that the spatial economy evolves according to the history presented in section 4 and that jointly constitute a proof of the main results of the paper (propositions $2-6$).

Result 7 Along the interval of communication costs given by

$$\underbrace{\left\{\frac{(1-\theta)\left[(1-\mu)+\mu(1-\alpha)(1-\mu')\right]-\theta K_1}{2K_1\theta}\right\}^{\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}}\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{\mu(1-\alpha)}}}_{T_{spec1}} < \tau \leq T_{max} \tag{60}$$

there is a unique stable equilibrium that involves activity s being produced in locations $\{S2, N1, N2\}$, u being produced in both Southern cities while management (M) is produced in $N2$. Moreover, along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, and skill polarization across space within countries.

Proof: In this and the following results, I will focus attention on proving the comparative static results. The proof of the existence and stability of the posited equilibria, as well as their uniqueness within the class of stable equilibria largely follows the same template as the proof of Proposition 1 undertaken in the previous section. In order to prove the comparative static results outlined above, I again first need to establish some intermediate results.

Result 7.1 For $\tau < T_{max}$ a reduction in communication costs is associated with a decline in the relative price of the urban good (i.e. $\frac{\partial}{\partial\tau}\left(\frac{p_2}{p_1}\right) > 0$).

Along the interval $T_{spec1} < \tau < T_{max}$ the equilibrium configuration outlined above implies that the following must hold:

$$\gamma^{\epsilon}p_1^{1-\epsilon} + (1-\gamma)^{\epsilon}p_2^{1-\epsilon} = 1$$

$$p_1 = \frac{w_S^U}{\xi_{1S}} = \frac{w_N^U}{\xi_{1N}}$$

$$p_2 = \left(\frac{p_u}{\theta}\right)^{\theta}\left(\frac{p_s}{1-\theta}\right)^{1-\theta}$$

$$c_{S2}(s) = c_{N1}(s) = c_{N2}(s) = p_s \tag{61}$$

$$c_{S1}(u) = c_{S2}(u) = p_u \tag{62}$$

Further, the equality $c_{N1}(s) = c_{N2}(s)$ embedded in equation (61) above implies that rental rates are equalized across Northern cities (i.e. $r_{N2} = r_{N1} = r_N$) whereas the equality $c_{S1}(u) = c_{S2}(u)$ implies that $r_{S2} = K_1 r_{S1}$ where $K_1 = A^{\frac{\beta}{1-\beta}} > 1$. Expanding and simplifying the equality $c_{S2}(s) = c_{N1}(s)$ embedded in equation (61) yields:

$$r_N = \underbrace{\left(\frac{\xi_{1S}}{\xi_{1N}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{(1-\beta)(1-\mu)}} \tau^{\frac{\mu(1-\alpha)}{(1-\beta)(1-\mu)}}}_{G(\tau)} r_{S2} \tag{63}$$

Moving to derive expressions for the prices of the various urban commodities in equilibrium, I obtain:

$$p_u = \left(\frac{1}{A}\frac{w_S^U}{\beta}\right)^{\beta}\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}$$

which can be rewritten:

$$p_u = \underbrace{\left(\frac{1}{A}\frac{\xi_{1S}}{\beta}\right)^{\beta}\left(\frac{1}{1-\beta}\right)^{1-\beta}}_{K_2} p_1^{\beta} r_{S2}^{1-\beta} \tag{64}$$

Further, for s I obtain:

$$p_s = \left[\frac{1}{\mu}\left(\frac{w_S^U}{(1-e)\alpha}\frac{1}{A^{\rho}}\right)^{\alpha}\left(\frac{p_M\tau}{1-\alpha}\right)^{1-\alpha}\right]^{\mu}\left[\frac{1}{1-\mu}\left(\frac{w_S^U}{\beta}\frac{1}{A}\right)^{\beta}\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}\right]^{1-\mu}$$

which I again write in more compact format:

$$p_s = K_3 p_1^{\alpha\mu+\beta(1-\mu)} r_{S2}^{(1-\beta)(1-\mu)} p_M^{\mu(1-\alpha)} \tau^{\mu(1-\alpha)} \tag{65}$$

where K_3 groups an expression given entirely by parameters of the model:

$$K_3 = \left[\frac{1}{\mu}\left(\frac{\xi_{1S}}{(1-e)\alpha}\frac{1}{A^{\rho}}\right)^{\alpha}\left(\frac{1}{1-\alpha}\right)^{1-\alpha}\right]^{\mu}\left[\frac{1}{1-\mu}\left(\frac{\xi_{1S}}{\beta}\frac{1}{A}\right)^{\beta}\left(\frac{1}{1-\beta}\right)^{1-\beta}\right]^{1-\mu}$$

Undertaking the same procedure of collapsing expressions containing only parameters into constants I obtain the following expression for the price of management:

$$p_M = K_4 p_1^{[\mu'+\beta(1-\mu')]} r_N^{(1-\beta)(1-\mu')} \tag{66}$$

where I note that:

$$r_N = G(\tau) r_{S2}$$
$$G(\tau) = \underbrace{\left(\frac{\xi_{1S}}{\xi_{1N}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{(1-\beta)(1-\mu)}}}_{K_5} \tau^{\frac{\mu(1-\alpha)}{(1-\beta)(1-\mu)}}$$

I can thus rewrite (63) as:

$$r_N = K_5 r_{S2} \tau^{\frac{\mu(1-\alpha)}{(1-\beta)(1-\mu)}} \tag{67}$$

Plugging this last equation into (66) and continuing to collect parameters in constants I write:

$$p_M = K_6 p_1^{[\mu' + \beta(1-\mu')]} r_{S2}^{(1-\beta)(1-\mu')} \tau^{\mu(1-\alpha)\frac{1-\mu}{1-\mu'}} \tag{68}$$

Whereas plugging equation (68) into equation (65) yields the following expression for the price of intermediate s:

$$p_s = K_7 p_1^{\mu(1-\alpha)[\mu'+\beta(1-\mu')]+\alpha\mu+\beta(1-\mu)} r_{S2}^{(1-\beta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]} \times \tau^{\mu(1-\alpha)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} \tag{69}$$

The expression for the price of the urban good (good 2) can also be rewritten:

$$p_2 = K_8 p_u^{\theta} p_s^{1-\theta} \tag{70}$$

Plugging (69) and (64) into (70) yields:

$$\begin{aligned} p_2 = {} & K_9 p_1^{1-(1-\beta)(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}]} r_{S2}^{(1-\beta)(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}]} \\ & \times \tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} \end{aligned} \tag{71}$$

which can be rewritten

$$\frac{p_2}{p_1} = K_9 \left(\frac{r_{S2}}{p_1}\right)^{(1-\beta)(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}]} \tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} \tag{72}$$

Imposing global market clearing conditions on labor and land markets gives us the equations:

$$\begin{aligned} L^S \xi_{1S} p_1 + L^N \xi_{1N} p_1 &= Y_1 + \beta\theta Y_2 + [\alpha\mu + \beta(1-\mu)](1-\theta)Y_2 \\ &\quad + (1-\theta)\mu(1-\alpha)[\mu' + \beta(1-\mu')]Y_2 \\ (r_{S1} + r_{S2} + r_{N1} + r_{N2})\overline{N} &= \theta(1-\beta)Y_2 + (1-\beta)(1-\mu)(1-\theta)Y_2 \\ &\quad + (1-\theta)Y_2\mu(1-\alpha)[(1-\beta)(1-\mu')] \end{aligned}$$

Taking into account the relative price of land across cities in equilibrium I can write:

$$\begin{aligned} r_{S2}(\frac{1}{K_1} + 1 + 2G(\tau))\overline{N} &= \theta(1-\beta)Y_2 + (1-\beta)(1-\mu)(1-\theta)Y_2 \\ &\quad + (1-\theta)Y_2\mu(1-\alpha)[(1-\beta)(1-\mu')] \end{aligned} \tag{73}$$

which can be rewritten

$$r_{S2} = \frac{(1-\beta)(1-\theta)}{\left[\frac{1}{K_1} + 1 + 2G(\tau)\right]} \left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right] \frac{Y_2}{\overline{N}} \tag{74}$$

Similarly the price of the traditional good (good 1) is given by the following expression:

$$p_1 = \frac{Y_2}{L^S\xi_{1S} + L^N\xi_{1N}} \left[\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon} \left(\frac{p_2}{p_1}\right)^{\epsilon-1} + \beta\theta + (1-\theta)[\alpha\mu + \beta(1-\mu)] + \mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')] \right] \tag{75}$$

Dividing (74) by (75) leads to the equation

$$\frac{r_{S2}}{p_1} = \frac{[L^S\xi_{1S} + L^N\xi_{1N}] \overbrace{(1-\beta)(1-\theta)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]}^{K_{10}}}{\overline{N}\left[\frac{1}{K_1} + 1 + 2G(\tau)\right]\left[\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon}\left(\frac{p_2}{p_1}\right)^{\epsilon-1} + \beta\theta + (1-\theta)[\alpha\mu + \beta(1-\mu)] + \mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]\right]} \tag{76}$$

Which can be rewritten

$$\frac{r_{S2}}{p_1} = \frac{[L^S\xi_{1S} + L^N\xi_{1N}]K_{10}}{\overline{N}\left[\frac{1}{K_1} + 1 + 2G(\tau)\right]\left[\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon}\left(\frac{p_2}{p_1}\right)^{\epsilon-1} + 1 - K_{10}\right]} \tag{77}$$

Plugging (77) into (72), collecting terms yields

$$\frac{p_2}{p_1} = K_{11}\left\{\underbrace{\frac{1}{\left[\frac{1}{K_1} + 1 + 2G(\tau)\right]\left[\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon}\left(\frac{p_2}{p_1}\right)^{\epsilon-1} + 1 - K_{10}\right]}}_{Exp}\right\}^{K_{10}} \tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} \tag{78}$$

I can thus set up a function:

$$F(\frac{p_2^*}{p_1^*}, \tau) = \frac{p_2^*}{p_1^*} - K_{11}Exp^{K_{10}}\tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} = 0 \tag{79}$$

Applying the implicit function theorem to the function above yields:

$$\frac{\partial \frac{p_2^*}{p_1^*}}{\partial\tau} = \frac{-\frac{\partial F}{\partial \tau}}{\frac{\partial F}{\partial \frac{p_2^*}{p_1^*}}} \tag{80}$$

Computing the relevant partial derivatives I obtain:

$$\begin{aligned} \frac{\partial F}{\partial \tau} &= K_{11}Exp^{K_{10}}\tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]-1} \\ &\times \left\{ K_{10}\frac{2G'(\tau)\tau}{\left[\frac{1}{K_1} + 1 + 2G(\tau)\right]} - \mu(1-\alpha)(1-\theta)\left[\mu(1-\alpha)\frac{1-\mu'}{1-\mu} + 1\right] \right\} \end{aligned} \tag{81}$$

$$\frac{\partial F}{\partial \frac{p_2}{p_1}} = 1 + K_{11}K_{10}Exp^{K_{10}}\frac{(\epsilon-1)\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon}\left(\frac{p_2}{p_1}\right)^{\epsilon-2}}{\left[\left(\frac{\gamma}{1-\gamma}\right)^{\epsilon}\left(\frac{p_2}{p_1}\right)^{\epsilon-1} + 1 - K_{10}\right]}\tau^{\mu(1-\alpha)(1-\theta)[\mu(1-\alpha)\frac{1-\mu'}{1-\mu}+1]} \tag{82}$$

Given that the right hand side of equation (82) is positive the sign of the expression in equation (80) is pinned down by the sign of the expression in the curly brackets in equation (81). It is straightforward to show that for $\tau < T_{max}$ this latter expression is negative which implies that $\frac{\partial \frac{p_2^*}{p_1^*}}{\partial \tau} > 0$ which completes the proof of Result 7.1.

Result 7.2   For $T_{spec1} < \tau < T_{max}$, any reduction in international communication costs is associated with an increase in world output.

Proof: The result above is straightforward and can be obtained by expressing equilibrium output via equation (6) (the value of total output is equivalent to aggregate utility as we've chose utility units as the numeraire), expanding the expression to obtain an equation expressed in terms of the equilibrium allocations of land and labor to the production of various commodities, and totally differentiating the resulting expression by making use of the envelope theorem.

Result 7.3   For $T_{spec1} < \tau < T_{max}$, any reduction in international communication costs is associated with an increase in the relative expenditure on the urban good (i.e. $\frac{\partial \frac{Y_2}{Y_1}}{\partial \tau} < 0$).

Proof: The result above can be obtained by differentiating equation (21) with respect to τ and noting Result 7.1.

Thus I have so far shown that decreases in international communication costs along the interval $T_{spec1} < \tau < T_{max}$ are associated with reduction in the relative price of the urban good, growth in world output and in the expenditure share of the urban good (i.e.$\tau \uparrow \Rightarrow \frac{p_2}{p_1} \downarrow, Y \uparrow, \frac{Y_2}{Y_1} \uparrow$). In what follows I show that it is also associated with an increase in the relative size of skilled cities in both North and South (i.e. an increase in the relative size of $S2$ and $N2$ vis-a-vis $S1$ and $N1$ respectively).

In a stable equilibrium with $T_{spec1} < \tau < T_{max}$, it must be the case, in light of the first part of result 7 that the following conditions hold:

$$Y_u^{S1} + Y_u^{S2} = Y_u = \theta Y_2 \tag{83}$$

$$Y_s^{S2} + Y_s^{N1} + Y_s^{N2} = Y_s = (1-\theta)Y_2 \tag{84}$$

As I have already established that in equilibrium, along the relevant range of communication costs, rental rates of the two Northern cities are equalized, I can write:

$$r_{N1} = r_{N2} = r_N$$

$$\frac{(1-\beta)(1-\mu)Y_s^{N1}}{\overline{N}} = \frac{(1-\beta)(1-\mu)Y_s^{N2} + \mu(1-\alpha)(1-\beta)(1-\mu')Y_s}{\overline{N}}$$

where the latter equation can be re-ordered:

$$Y_s^{N2} = Y_s^{N1} - \mu(1-\alpha)\frac{1-\mu}{1-\mu'}Y_s \tag{85}$$

In equilibrium I also have that:

$$r_N = G(\tau) r_{s2}$$
$$\frac{(1-\beta)(1-\mu)Y_s^{N1}}{\overline{N}} = G(\tau)\frac{(1-\beta)(1-\mu)Y_s^{S2} + (1-\beta)Y_u^{S2}}{\overline{N}}$$

where again the latter equation can be simplified and re-ordered:

$$(1-\mu)Y_s^{N1} = G(\tau)[(1-\mu)Y_s^{S2} + Y_u^{S2}] \tag{86}$$

Finally, locational equilibrium across Southern cities imposes:

$$r_{S2} = K_1 r_{S1}$$
$$\frac{(1-\beta)(1-\mu)Y_s^{S2} + (1-\beta)Y_u^{S2}}{\overline{N}} = K_1 \frac{(1-\beta)Y_u^{S1}}{\overline{N}}$$

where the latter equation can be simplified to:

$$(1-\mu)Y_s^{S2} + Y_u^{S2} = K_1 Y_u^{S1} \tag{87}$$

Thus, I can set up a system of five equations and five unknowns (the unknowns are Y_u^{S1}, Y_u^{S2}, Y_s^{S2}, Y_s^{N1}, Y_s^{N2}, whereas Y_u, Y_s and Y_2 are considered known):

$$\begin{cases} (1-\mu)Y_s^{N1} = G(\tau)[(1-\mu)Y_s^{S2} + Y_u^{S2}] \\ (1-\mu)Y_s^{S2} + Y_u^{S2} = K_1 Y_u^{S1} \\ Y_s^{N1} = Y_s^{N2} + \mu(1-\alpha)\frac{1-\mu}{1-\mu'}Y_s \\ Y_u^{S1} + Y_u^{S2} = Y_u \\ Y_s^{S2} + Y_s^{N1} + Y_s^{N2} = Y_s \end{cases} \tag{88}$$

Solving the system of equations above yields the following expressions of the unknowns as a function of Y_2, the global value of urban output:

$$Y_u^{S1} = \frac{(1-\theta)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]}{[1 + (1 + 2G(\tau))\,K_1]}Y_2 \tag{89}$$
$$Y_u^{S2} = \frac{\theta[1+2G(\tau)]K_1 - (1-\theta)[(1-\mu) + \mu(1-\alpha)(1-\mu')]}{[1 + (1+2G(\tau))K_1]}Y_2 \tag{90}$$
$$Y_s^{S2} = \frac{1}{1-\mu}\frac{(1+K_1)(1-\theta)[(1-\mu) + \mu(1-\alpha)(1-\mu')]Y_2 - 2\theta K_1 G(\tau)Y_2}{1 + [1+2G(\tau)]K_1} \tag{91}$$
$$Y_s^{N1} = \frac{1}{1-\mu}\frac{K_1 G(\tau)(1-\theta)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]}{1 + [1+2G(\tau)]K_1}Y_2 \tag{92}$$
$$Y_s^{N2} = \frac{1-\theta}{1-\mu}\frac{K_1 G(\tau)\left[(1-\mu) - \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right] - \mu(1-\alpha)(1-\mu')(1+K_1)}{1 + [1+2G(\tau)]K_1}Y_2 \tag{93}$$

Some further useful expressions are:

$$Y_s^{S2} = \frac{1+K_1}{1-\mu} Y_u^{S1} - \frac{1}{1-\mu} Y_u \tag{94}$$

$$Y_M^{N2} = \mu(1-\alpha)(1-\theta)Y_2 \tag{95}$$

Where the former equation is equivalent to equation (90). Finally, I am ready to move to the analysis of the populations of cities, which can be expressed as a ratio of the wage bill of the workers at each location divided by the typical wage. In the South I have:

$$Pop_{S1} = \frac{\beta Y_u^{S1}}{\xi_{1S} p_1} \tag{96}$$

$$Pop_{S2} = \frac{\beta Y_u^{S2} + [\alpha\mu + \beta(1-\mu)] Y_s^{S2}}{\xi_{1S} p_1} \tag{97}$$

Plugging equations (83) and (93) into equation (97) and simplifying I obtain

$$Pop_{S2} = \frac{\left[\alpha \frac{\mu}{1-\mu}(1+K_1) + \beta K_1\right] Y_u^{S1} - \alpha \frac{\mu}{1-\mu} Y_u}{\xi_{1S} p_1} \tag{98}$$

Dividing (98) by (96) yields

$$\frac{Pop_{S2}}{Pop_{S1}} = \frac{\left[\alpha \frac{\mu}{1-\mu}(1+K_1) + \beta K_1\right] Y_u^{S1} - \alpha \frac{\mu}{1-\mu} Y_u}{\beta Y_u^{S1}} \tag{99}$$

Which can be rewritten:

$$\frac{Pop_{S2}}{Pop_{S1}} = \left[\frac{\alpha}{\beta} \frac{\mu}{1-\mu}(1+K_1) + K_1\right] - \frac{\alpha}{\beta} \frac{\mu}{1-\mu} \frac{Y_u}{Y_u^{S1}} \tag{100}$$

Differentiating (100) with respect to τ I obtain:

$$\frac{\partial \frac{Pop_{S2}}{Pop_{S1}}}{\partial \tau} = -\frac{\alpha}{\beta} \frac{\mu}{1-\mu} \frac{\partial \frac{Y_u}{Y_u^{S1}}}{\partial \tau} \tag{101}$$

From (83) and (89) I obtain the following expression for Y_u / Y_u^{S1}:

$$\frac{Y_u}{Y_u^{S1}} = \frac{\theta[(1+K_1) + 2K_1 G(\tau)]}{(1-\theta)\left[(1-\theta) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]} \tag{102}$$

Differentiating (102) with respect to τ yields:

$$\frac{\partial \frac{Y_u}{Y_u^{S1}}}{\partial \tau} = \frac{2K_1}{(1-\theta)\left[(1-\theta) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]} G'(\tau) > 0 \tag{103}$$

Which implies from equation (101) that $\frac{\partial \frac{Pop_{S2}}{Pop_{S1}}}{\partial \tau} < 0$ which proves that along the interval of communication costs $T_{spec1} < \tau < T_{max}$, reductions in communication costs are associated with an increase in the relative size of the advanced Southern city $S2$ (i.e. $\tau \downarrow \Rightarrow \frac{Pop_{S2}}{Pop_{S1}} \uparrow$). The proof that the same happens in the North proceeds analogously:

$$Pop_{N1} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{N1}}{\xi_{1N} p_1} \tag{104}$$

$$Pop_{N2} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{N2} + [\mu' + \beta(1-\mu')]\mu(1-\alpha)(1-\theta)Y_2}{\xi_{1N} p_1} \tag{105}$$

Making use of (88) I can rewrite (105) as follows:

$$Pop_{N2} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{N1} + \mu(1-\alpha)(1-\theta)\left[\mu' - \alpha\mu\frac{1-\mu'}{1-\mu}\right]Y_2}{\xi_{1N} p_1} \tag{106}$$

Dividing equation (106) by (104) yields:

$$\frac{Pop_{N2}}{Pop_{N1}} = 1 + \frac{\mu(1-\alpha)(1-\theta)\left[\mu' - \alpha\mu\frac{1-\mu'}{1-\mu}\right]}{\alpha\mu + \beta(1-\mu)}\frac{Y_2}{Y_s^{N1}} \tag{107}$$

Differentiating (107) with respect to τ yields

$$\frac{\partial \frac{Pop_{N2}}{Pop_{N1}}}{\partial \tau} = \frac{\mu(1-\alpha)(1-\theta)\left[\mu' - \alpha\mu\frac{1-\mu'}{1-\mu}\right]}{\alpha\mu + \beta(1-\mu)}\frac{\partial \frac{Y_2}{Y_s^{N1}}}{\partial \tau} \tag{108}$$

To establish the sign of the expression above, I employ equation (92) to derive an expression for Y_2/Y_s^{N1}:

$$\frac{Y_2}{Y_s^{N1}} = \frac{(1-\mu)[(1+K_1) + 2K_1 G(\tau)]}{K_1 G(\tau)(1-\theta)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]} \tag{109}$$

which can be rewritten by grouping all the terms in parameters into a large constant term CT:

$$\frac{Y_2}{Y_s^{N1}} = CT\left[\frac{1+K_1}{G(\tau)} + 2K_1\right] \tag{110}$$

Differentiating the last equation with respect to τ I obtain:

$$\frac{\partial \frac{Y_2}{Y_s^{N1}}}{\partial \tau} = (1+K_1)CT(-1)\frac{G'(\tau)}{[G(\tau)]^2} < 0 \tag{111}$$

Corroborating the result above with equation (108) leads to the conclusion that $\partial(Pop_{N2}/Pop_{N1})/\partial\tau < 0$ which completes the proof that along the interval of communication costs covered by result 7, a reduction in communication frictions is associated with an increase in the relative size of the skilled city (city $N2$) also in the North.

I am now ready to move to the results concerning worldwide urbanization. From the identity equating the income of workers with total labor costs, I can write:

$$\xi_{1S}L^S + \xi_{1N}L^N = Y_1 + \beta\theta Y_2 + [\alpha\mu + \beta(1-\mu)](1-\theta)Y_2$$
$$+ (1-\theta)Y_2\mu(1-\alpha)[\mu' + \beta(1-\mu')]$$

Noting that the entire world output is used up remunerating labor and land, I can also write the following accounting identity for the global remuneration of labor:

$$\xi_{1S}L^S + \xi_{1N}L^N = Y - \theta(1-\beta)Y_2 - (1-\beta)(1-\mu)(1-\theta)Y_2$$
$$- (1-\theta)Y_2\mu(1-\alpha)(1-\beta)(1-\mu')$$

which can be rewritten to give us the following expression for the price of the traditional good:

$$p_1 = \frac{1}{\xi_{1S}L^S + \xi_{1N}L^N}\left\{Y - (1-\beta)(1-\mu)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]Y_2\right\} \tag{112}$$

Dividing the previous equation by Y I obtain:

$$\frac{p_1}{Y} = \frac{1}{\xi_{1S}L^S + \xi_{1N}L^N}\left\{1 - (1-\beta)(1-\mu)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]\frac{Y_2}{Y}\right\} \tag{113}$$

Differentiating (113) with respect to τ yields:

$$\frac{\partial}{\partial\tau}\left(\frac{p_1}{Y}\right) = -(1-\beta)(1-\theta)\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right]\frac{\partial}{\partial\tau}\left(\frac{Y_2}{Y}\right) > 0 \tag{114}$$

Where the final inequality emerges from the fact that I have shown in Result 7.3 that $\frac{\partial}{\partial\tau}\left(\frac{Y_2}{Y_1}\right) < 0$ which is equivalent to $\frac{\partial}{\partial\tau}\left(\frac{Y_2}{Y}\right) < 0$. Thus I have that $\tau \downarrow \Rightarrow \frac{p_1}{Y} \downarrow \Rightarrow \frac{Y}{p_1} \uparrow \Rightarrow \frac{Y_2}{p_1} \uparrow$.

I can now show that decreases in international communication costs are associated with rising world urbanization. From equation (91) I can write, in compact form:

$$Y_s^{S2} = f(\tau)Y_s = f(\tau)(1-\theta)Y_2$$
$$Y_s^{N1} + Y_s^{N2} = [1-f(\tau)]Y_s = [1-f(\tau)](1-\theta)Y_2$$

with the property that $f'(\tau) < 0$. Moving on to computing worldwide urban population I can write:

$$\text{Urban population} = \frac{\beta\theta Y_2}{\xi_{1S}p_1} + \frac{[\alpha\mu + \beta(1-\mu)](1-\theta)f(\tau)Y_2}{\xi_{1S}p_1}$$
$$+\frac{[\alpha\mu + \beta(1-\mu)](1-\theta)(1-f(\theta))Y_2}{\xi_{1N}p_1} + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]Y_2}{\xi_{1N}p_1} \tag{115}$$

which can be rewritten:

$$\text{Urban population} = \frac{Y_2}{p_1}\left\{\frac{\beta\theta}{\xi_{1S}} + [\alpha\mu + \beta(1-\mu)](1-\theta)\left[\frac{\xi_{1S} + (\xi_{1N} - \xi_{1S})f(\tau)}{\xi_{1S}\xi_{1N}}\right]\right.$$
$$\left. + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]}{\xi_{1N}}\right\}$$

Differentiating the previous equation with respect to τ then yields:

$$\frac{\partial}{\partial \tau}\,(\text{Urban population}) = \frac{\partial \frac{Y_2}{p_1}}{\partial \tau}_{<0}\{\ldots\} + \frac{Y_2}{p_1}\frac{[\alpha\mu + \beta(1-\mu)](1-\theta)}{\xi_{1S}\xi_{1N}}(\xi_{1N} - \xi_{1S})f'(\tau)_{<0} < 0 \tag{116}$$

Which completes the proof that along the interval of interest, reductions in communication costs are related to increasing in total urban population, and hence urbanization: $\tau \downarrow \Rightarrow$ World Urban Population $\uparrow \Rightarrow$ World Urbanization $\uparrow$. I am finally ready to discuss the issue of skill polarization across space (within countries). In the South, I aim to sign the expression:

$$\frac{\partial}{\partial \tau}\left(\frac{H_{S2}}{L_{S2}} - \frac{H_{S1}}{L_{S1}}\right)$$

But for stable equilibria, we already know that $\frac{H_{S1}}{L_{S1}} = 0$, which yields:

$$\frac{\partial}{\partial \tau}\left(\frac{H_{S2}}{L_{S2}} - \frac{H_{S1}}{L_{S1}}\right) = \frac{\partial}{\partial \tau}\frac{H_{S2}}{L_{S2}}$$

I now derive an expression for $\frac{H_{S2}}{L_{S2}}$:

$$H_{S2} = \frac{\alpha\mu Y_s^{S2}}{\xi_{1S}p_1} \tag{117}$$

$$L_{S2} = \frac{\beta(1-\mu)Y_s^{S2}}{\xi_{1S}p_1} + \frac{\beta Y_u^{S2}}{\xi_{1S}p_1} \tag{118}$$

$$\frac{H_{S2}}{L_{S2}} = \frac{\alpha\mu Y_s^{S2}}{\beta(1-\mu)Y_s^{S2} + \beta Y_u^{S2}} \tag{119}$$

where I can rewrite the last equation:

$$\frac{H_{S2}}{L_{S2}} = \frac{\alpha\mu}{\beta(1-\mu) + \beta\frac{Y_u^{S2}}{Y_s^{S2}}} \tag{120}$$

Differentiating the previous equation with respect to τ yields the equation:

$$\frac{\partial}{\partial \tau}\left(\frac{H_{S2}}{L_{S2}}\right) = -\alpha\mu\frac{1}{\left[\beta(1-\mu) + \beta\left(\frac{Y_u^{S2}}{Y_s^{S2}}\right)\right]^2}\frac{\partial\left(\frac{Y_u^{S2}}{Y_s^{S2}}\right)}{\partial \tau} \tag{121}$$

Where the sign of the RHS of equation (121) is determined by the sign of the last partial derivative. I proceed to evaluate this sign:

$$\frac{Y_u^{S2}}{Y_s^{S2}} = \frac{(1-\mu)\left\{\theta[1+2G(\tau)]K_1 - (1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]\right\}}{(1+K_1)(1-\theta)\left[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}\right] - \theta(1+K_1)}$$

$$\frac{\partial}{\partial \tau}\left(\frac{Y_u^{S2}}{Y_s^{S2}}\right) = \frac{2(1-\mu)K_1\theta G'(\tau)}{(1+K_1)(1-\theta)\left[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}\right] - \theta(1+K_1)} > 0$$

which implies that $\frac{\partial}{\partial \tau}\left(\frac{H_{S2}}{L_{S2}}\right) < 0$ which shows that along the interval of communication costs covered by result 7, reductions in communication costs are associated with skill polarization across southern cities. Turning our attention to the North I aim to sign:

$$\frac{\partial}{\partial \tau}\left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right)$$

However, given that $N1$ remains completely specialized in activity s along the entire interval of communication costs that forms the object of result 7 I can write:

$$\frac{H_{N1}}{L_{N1}} = \frac{\frac{\alpha\mu Y_s^{N1}}{\xi_{1N} p_1}}{\frac{\beta(1-\mu)Y_s^{N1}}{\xi_{1N} p_1}} = \frac{\alpha\mu}{\beta(1-\mu)}$$
$$\frac{\partial}{\partial\tau}\frac{H_{N1}}{L_{N1}} = 0$$

which implies I can write:

$$\frac{\partial}{\partial\tau}\left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right) = \frac{\partial}{\partial\tau}\frac{H_{N2}}{L_{N2}}$$

Focusing on deriving an expression for H_{N2}/L_{N2} I can write:

$$\frac{H_{N2}}{L_{N2}} = \frac{\frac{\alpha\mu Y_s^{N2}}{\xi_{1N} p_1} + \frac{\mu' Y_M}{\xi_{1N} p_1}}{\frac{\beta(1-\mu)Y_s^{N2}}{\xi_{1N} p_1} + \frac{\beta(1-\mu')Y_M}{\xi_{1N} p_1}} \tag{122}$$

which can be rewritten:

$$\frac{H_{N2}}{L_{N2}} = \frac{\alpha\mu + \mu' \frac{Y_M}{Y_s^{N2}}}{\beta(1-\mu) + \beta(1-\mu)\frac{Y_M}{Y_s^{N2}}} \tag{123}$$

Differentiating the previous equation I obtain:

$$\frac{\partial}{\partial\tau}\frac{H_{N2}}{L_{N2}} = \frac{[\mu'\beta(1-\mu) - \alpha\mu\beta(1-\mu)]\frac{\partial}{\partial\tau}\frac{Y_M}{Y_s^{N2}}}{\left[\beta(1-\mu) + \beta(1-\mu')\frac{Y_M}{Y_s^{N2}}\right]^2} \tag{124}$$

Moving to obtain an expression for the final partial derivative above, I can write

$$\frac{Y_M^{N2}}{Y_s^{N2}} = \frac{\mu(1-\alpha)(1-\theta)Y_2}{\frac{1-\theta}{1-\mu}Y_2\frac{K_1 G(\tau)\left[(1-\mu)-\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}\right]-\mu(1-\alpha)(1-\mu')(1+K_1)}{1+[1+2G(\tau)]K_1}}$$

which after some manipulations can be rewritten

$$\frac{Y_M^{N2}}{Y_s^{N2}} = \frac{\mu(1-\alpha)(1-\mu)\left[\frac{1+K_1}{G(\tau)} + 2K_1\right]}{K_1\left[(1-\mu) + \mu(1-\alpha)(1-\mu') + \frac{\theta}{1-\theta}\right] - \mu(1-\alpha)(1-\mu')\frac{1+K_1}{G(\tau)}}$$

From the above equation and the observation that $G'(\tau) > 0$ it is clear that:

$$\frac{\partial}{\partial\tau}\frac{Y_M^{N2}}{Y_s^{N2}} < 0 \tag{125}$$

which implies that $\frac{\partial}{\partial\tau}\frac{H_{N2}}{L_{N2}} < 0$ which establishes our final statement from result 7 namely that along the interval of communication costs $T_{spec1} < \tau < T_{max}$, reductions in communication costs are associated with skill divergence across Northern cities. (i.e. $\tau \downarrow \Rightarrow \frac{H_{N2}}{L_{N2}} \uparrow \Rightarrow \left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right) \uparrow$).

In what follows I move to establish results for the next range of communication costs, which are described as stage 2 of (communication induced) globalization.

Result 8 Along the interval of communication costs given by

$$\underbrace{\left\{\frac{\mu(1-\alpha)(1-\mu')}{(1-\mu)-\mu(1-\alpha)(1-\mu')}\right\}^{\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}}\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{\mu(1-\alpha)}}}_{T_{spec2}} < \tau \leq T_{spec1} \tag{126}$$

the unique stable equilibrium involves activity s being produced in locations $\{S2, N1, N2\}$, u being produced only in Southern location $S1$ while management (M) is produced only in $N2$. Moreover, along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, skill polarization across Northern cities and divergence in real estate prices across Southern cities, with relatively skilled cities always favored.

Proof: As before, I focus on the comparative static statements contained in Result 8 (proof of existence and uniqueness of the stable equilibrium configuration described above is analogous to the proof of Proposition 1). I first need to establish some intermediate results.

Result 8.1 For $T_{spec2} < \tau < T_{spec1}$ a reduction in communication costs is associated with a decline in the relative price of the urban good (i.e. $\frac{\partial}{\partial\tau}\left(\frac{p_2}{p_1}\right) > 0$)

Proof: Similar to Result 7.1.

Result 8.2 For $T_{spec2} < \tau < T_{spec1}$ a reduction in international communication costs is associated with an increase in world output.

Proof: Similar to Result 7.2.

Result 8.3 For $T_{spec2} < \tau < T_{spec1}$ any reduction in international communication costs is associated with an increase in relative expenditure on the urban good (i.e. $\frac{\partial \frac{Y_2}{Y_1}}{\partial\tau} < 0$)

Proof: Similar to Result 7.3

I now focus on the statements concerning urbanization and the relative performance of locations within countries. Along the interval of communication costs covered by Result 8 stable equilibrium configurations are governed by:

$$\gamma^{\epsilon}p_1^{1-\epsilon} + (1-\gamma)^{\epsilon}p_2^{1-\epsilon} = 1$$

$$p_1 = \frac{w_S^U}{\xi_{1S}} = \frac{w_N^U}{\xi_{1N}}$$

$$p_2 = \left(\frac{p_u}{\theta}\right)^{\theta}\left(\frac{p_s}{1-\theta}\right)^{1-\theta}$$

$$c_{S2}(s) = c_{N1}(s) = c_{N2}(s) = p_s \tag{127}$$

$$c_{S1}(u) = p_u \tag{128}$$

Given the configuration of equilibria along this range of communication costs, I can write:

$$Y_u^{S1} = Y_u = \theta Y_2 \tag{129}$$

$$r_{S1}\overline{N} = (1-\beta)\theta Y_2 \tag{130}$$

$$r_{S2}\overline{N} = (1-\beta)(1-\mu)Y_s^{S2} \tag{131}$$

$$r_{N1}\overline{N} = (1-\beta)(1-\mu)Y_s^{N1} \tag{132}$$

$$r_{N2}\overline{N} = (1-\beta)(1-\mu)Y_s^{N2} + (1-\beta)(1-\mu')Y_M^{N2} \tag{133}$$

Furthermore, from the equation $c_{S2}(s) = c_{N1}(s)$ I obtain (by expanding and simplifying) the equilibrium condition:

$$r_{N1} = G(\tau)r_{S2} \tag{134}$$

which given that both locations $S2$ and $N1$ are completely specialized in s yields the result:

$$Y_s^{N1} = G(\tau)Y_s^{S2} \tag{135}$$

From the symmetry of Northern cities, and given that equilibrium configurations in this range of communication costs involve skilled manufacturing (s) taking place in both Northern cities, it must be the case that $r_{N1} = r_{N2} = r_N$. Coupled with equations (132) and (133) this yields:

$$Y_s^{N1} - Y_s^{N2} = \frac{\mu(1-\alpha)(1-\theta)(1-\mu')}{1-\mu}Y_2 \tag{136}$$

Finally, for such configurations, we have the "accounting"identity:

$$Y_s^{S2} + Y_s^{N1} + Y_s^{N2} = Y_s = (1-\theta)Y_2 \tag{137}$$

Solving the system of equations generated by equations (135), (136) and (137) yields:

$$Y_s^{N1} = \frac{(1-\theta)Y_2\left[(1-\mu)+\mu(1-\alpha)(1-\mu')\right]}{(1-\mu)\left[2+\frac{1}{G(\tau)}\right]} \tag{138}$$

$$Y_s^{S2} = \frac{1}{G(\tau)}Y_s^{N1} = \frac{(1-\theta)Y_2\left[(1-\mu)+\mu(1-\alpha)(1-\mu')\right]}{(1-\mu)\left[2G(\tau)+1\right]} \tag{139}$$

Moving to derive expressions for the populations of various locations, for the South I obtain:

$$Pop_{S1} = \frac{\beta Y_u^{S1}}{\xi_{1S}p_1} \tag{140}$$

$$Pop_{S2} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{S2}}{\xi_{1S}p_1} \tag{141}$$

Thus the relative size of Southern cities is then given by:

$$\frac{Pop_{S2}}{Pop_{S1}} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{S2}}{\beta Y_u^{S1}} \tag{142}$$

Substituting into equation (141) the expression in equation (139) and noting that $Y_u^{S1} = Y_u = \theta Y_2$:

$$\frac{Pop_{S2}}{Pop_{S1}} = \frac{1-\theta}{\theta}\frac{[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{2G(\tau)+1}\frac{[\alpha\mu+\beta(1-\mu)]}{\beta(1-\mu)} \tag{143}$$

Differentiating the last equation with respect to τ yields

$$\frac{\partial}{\partial\tau}\frac{Pop_{S2}}{Pop_{S1}} = -2\frac{1-\theta}{\theta}\frac{[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{2G(\tau)+1}\frac{[\alpha\mu+\beta(1-\mu)]}{\beta(1-\mu)}G'(\tau) < 0 \tag{144}$$

This establishes that decreasing international communication frictions are associated with an increase in the relative size of the advanced city in the South (i.e $\tau \downarrow \Rightarrow \frac{Pop_{S2}}{Pop_{S1}} \uparrow$). Moving to confirm the same statement for the North, we have

$$Pop_{N1} = \frac{[\alpha\mu+\beta(1-\mu)]Y_s^{N1}}{\xi_{1N}p_1} \tag{145}$$

$$Pop_{N2} = \frac{[\alpha\mu+\beta(1-\mu)]Y_s^{N2} + [\mu'+\beta(1-\mu')]\mu(1-\alpha)(1-\theta)Y_2}{\xi_{1N}p_1} \tag{146}$$

Substituting for Y_s^{N2} in (146) from (136), taking the ratio of the two populations (to assess relative size) and simplifying the expression yields:

$$\frac{Pop_{N2}}{Pop_{N1}} = 1 + \frac{\mu(1-\alpha)(1-\theta)\left[\mu' - \alpha\mu\frac{1-\mu'}{1-\mu}\right]}{\alpha\mu+\beta(1-\mu)}\frac{Y_2}{Y_s^{N1}} \tag{147}$$

Differentiating the last equation with respect to τ yields:

$$\frac{\partial}{\partial\tau}\left(\frac{Pop_{N2}}{Pop_{N1}}\right) = \frac{\mu(1-\alpha)(1-\theta)\left[\mu' - \alpha\mu\frac{1-\mu'}{1-\mu}\right]}{\alpha\mu+\beta(1-\mu)}\frac{\partial\frac{Y_2}{Y_s^{N1}}}{\partial\tau} \tag{148}$$

To compute the final integral on the RHS above, I write:

$$\frac{Y_2}{Y_s^{N1}} = \frac{Y_2}{\frac{(1-\theta)G(\tau)Y_2[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{(1-\mu)[2G(\tau)+1]}}$$

$$\frac{Y_2}{Y_s^{N1}} = \frac{(1-\mu)\left[2+\frac{1}{G(\tau)}\right]}{(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]}$$

$$\frac{\partial}{\partial\tau}\frac{Y_2}{Y_s^{N1}} = -\frac{1-\mu}{(1-\theta)[(1-\mu)+\mu(1-\alpha)(1-\mu')]}\frac{1}{[G(\tau)]^2}G'(\tau) < 0 \tag{149}$$

Equations (149) and (148) yield the result that $\frac{\partial}{\partial\tau}\left(\frac{Pop_{N2}}{Pop_{N1}}\right) < 0$ which shows that reductions in communication costs are also associated with an increase in the relative size of the skilled cities in the North.

Similarly to the proof of Result 7 it can be shown that

$$\frac{\partial}{\partial\tau}\left(\frac{p_1}{Y}\right) = -(1-\beta)(1-\theta)\left[(1-\mu)+\mu(1-\alpha)(1-\mu')+\frac{\theta}{1-\theta}\right] \tag{150}$$

$$\frac{\partial}{\partial\tau}\frac{Y_2}{Y} < 0 \tag{151}$$

Which leads to the conclusion that: $\tau \downarrow \Rightarrow \frac{p_1}{Y} \downarrow \Rightarrow \frac{Y}{p_1} \uparrow \Rightarrow \frac{Y_2}{p_1} \uparrow$.

I can again express Y_s^{S2} as $Y_s^{S2} = f(\tau)Y_s$ and $Y_s^{N1} + Y_s^{N2} = [1-f(\tau)]Y_s$ with $f'(\tau) > 0$. With the above results in place, I am ready to analyze the statements concerning urbanization contained in Result 8:

$$\begin{aligned} \text{Urban population} = \frac{\beta\theta Y_2}{\xi_{1S} p_1} + \frac{[\alpha\mu + \beta(1-\mu)](1-\theta) Y_2 f(\tau)}{\xi_{1S} p_1} \\ + \frac{[\alpha\mu + \beta(1-\mu)](1-\theta)[1-f(\theta)] Y_2}{\xi_{1N} p_1} + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')] Y_2}{\xi_{1N} p_1} \end{aligned} \tag{152}$$

which can be rewritten

$$\begin{aligned} \text{Urban population} = \frac{Y_2}{p_1} \left\{ \frac{\beta\tau}{\xi_{1S}} + [\alpha\mu + \beta(1-\mu)](1-\theta) \left[\frac{\xi_{1S} + (\xi_{1N} - \xi_{1S}) f(\tau)}{\xi_{1S}\xi_{1N}} \right] \right. \\ \left. + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]}{\xi_{1N}} \right\} \end{aligned} \tag{153}$$

Differentiating the previous equation yields:

$$\frac{\partial}{\partial\tau} \text{Urban population} = \underbrace{\frac{\partial \frac{Y_2}{p_1}}{\partial\tau}}_{<0} \{\ldots\} + \frac{Y_2}{p_1} \frac{[\alpha\mu + \beta(1-\mu)](1-\theta)}{\xi_{1S}\xi_{1N}} (\xi_{1N} - \xi_{1S}) \underbrace{f'(\tau)}_{<0} < 0 \tag{154}$$

I conclude that along the interval of communication costs covered by result 8 we have that:

$\tau \downarrow \Rightarrow$ World urban population $\uparrow \Rightarrow$ World Urbanization $\uparrow$.

Moving to the evolution of the skill compositions of various locations (and in particular to the question of skill polarization across locations within countries) I explicitly solve for the skill ratios of Southern locations:

$$\frac{H_{S1}}{L_{S1}} = 0 \tag{155}$$

$$\frac{H_{S2}}{L_{S2}} = \frac{\alpha\mu}{\beta(1-\mu)} \tag{156}$$

$$\frac{\partial}{\partial\tau} \left(\frac{H_{S2}}{L_{S2}} - \frac{H_{S1}}{L_{S1}} \right) = 0 \tag{157}$$

where the latter result highlights the absence of movements in the relative skill endowments of Southern locations. On the other hand, in the North I have:

$$\frac{H_{N1}}{L_{N1}} = \frac{\alpha\mu}{\beta(1-\mu)} \tag{158}$$

$$\frac{H_{N2}}{L_{N2}} = \frac{\alpha\mu + \mu' \frac{Y_M^{N2}}{Y_s^{N2}}}{\beta(1-\mu) + \beta(1-\mu') \frac{Y_M^{N2}}{Y_s^{N2}}} \tag{159}$$

$$\frac{\partial}{\partial\tau} \left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}} \right) = \frac{\partial}{\partial\tau} \frac{H_{N2}}{L_{N2}} \tag{160}$$

Differentiating equation (159) with respect to τ yields

$$\frac{\partial}{\partial\tau} \frac{H_{N2}}{L_{N2}} = \frac{[\mu'\beta(1-\mu) + \alpha\mu\beta(1-\mu')] \frac{\partial}{\partial\tau} \left(\frac{Y_M^{N2}}{Y_s^{N2}} \right)}{\left[\beta(1-\mu) + \beta(1-\mu') \frac{Y_M^{N2}}{Y_s^{N2}} \right]^2} \tag{161}$$

Making use of equations (136) and (138) and noting that $Y_M^{N2} = \mu(1-\alpha)(1-\theta)Y_2$ we have:

$$\frac{Y_M^{N2}}{Y_s^{N2}} = \frac{\mu(1-\alpha)(1-\mu)\left[2+\frac{1}{G(\tau)}\right]}{[(1-\mu)-\mu(1-\alpha)(1-\mu')] - \frac{\mu(1-\alpha)(1-\mu')}{G(\tau)}} \tag{162}$$

Differentiating the above and signing the resulting expression yields:

$$\frac{\partial}{\partial\tau}\left(\frac{Y_M^{N2}}{Y_s^{N2}}\right) < 0 \Rightarrow \frac{\partial}{\partial\tau}\frac{H_{N2}}{L_{N2}} < 0 \Rightarrow \frac{\partial}{\partial\tau}\left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right) < 0 \tag{163}$$

which establishes that along the second stage of globalization, skill divergence in the North continues.

Finally, shifting the focus towards urban land markets, it is easy to see that in the North land prices across cities remain equalized (as they were in the previous stage of globalization) whereas in the South we have:

$$r_{S1}\overline{N} = (1-\beta)\tau Y_2$$

$$r_{S2}\overline{N} = (1-\beta)(1-\mu)Y_s^{S2}$$

$$\frac{r_{S2}}{r_{S1}} = \frac{1-\mu}{\theta}\frac{Y_s^{S2}}{Y_2} = \frac{1-\theta}{\theta}\frac{[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{[2G(\tau)+1]} \tag{164}$$

Differentiating equation (164) above with respect to τ yields:

$$\frac{\partial}{\partial\tau}\frac{r_{S2}}{r_{S1}} = -\frac{1-\theta}{\theta}\frac{[(1-\mu)+\mu(1-\alpha)(1-\mu')]}{[2G(\tau)+1]^2}2G'(\tau) < 0 \tag{165}$$

Where the last result indicates that along the second stage of globalization, reductions in the cost of communication are associated with divergence in the rental rates of land across Southern cities, with the advanced (skilled) city $S2$ favored (i.e. $\tau \downarrow \Rightarrow \frac{r_{S2}}{r_{S1}} \uparrow$).

I now proceed to the third stage of globalization.

Result 9 Along the interval of communication costs given by

$$\underbrace{\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha\mu+\beta(1-\mu)}{\mu(1-\alpha)}}\left[\frac{1-\theta}{\theta K_1}(1-\mu)\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\beta}{1-\beta}} - 1\right]^{-\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}}}_{T_{ovt}} < \tau < T_{spec2} \tag{166}$$

the unique stable equilibrium involves activity s being produced in locations $\{S2, N1\}$, u being produced only in Southern location $S1$ while management (M) is produced only in $N2$. Moreover, along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, divergence in real estate prices across cities in both North and South, with relatively skilled cities favored as well as absolute growth in the skilled Northern city $N2$.

Proof: I focus on the comparative static statements in Result 8. As in Result 7, I first need to establish some intermediate results.

Result 9.1 For $T_{ovt} < \tau < T_{spec2}$ a reduction in communication costs is associated with a decline in the relative price of the urban good (i.e. $\frac{\partial}{\partial \tau}\left(\frac{p_2}{p_1}\right) > 0$)

Proof: Similar to Result 7.1, 8.1.

Result 9.2 For $T_{ovt} < \tau < T_{spec2}$ a reduction in international communication costs is associated with an increase in world output.

Proof: Similar to Result 7.2, 8.2.

Result 9.3 For $T_{ovt} < \tau < T_{spec2}$ any reduction in international communication costs is associated with an increase in relative expenditure on the urban good (i.e. $\frac{\partial \frac{Y_2}{Y_1}}{\partial \tau} < 0$)

Proof: Similar to Result 7.3, 8.3

I now focus on urbanization and the relative performance of locations within countries. Along the interval of communication costs covered by Result 9 stable equilibrium configurations are governed by:

$$\begin{aligned}
r_{S1}\overline{N} &= (1-\beta)\theta Y_2 \\
r_{S2}\overline{N} &= (1-\beta)(1-\mu)Y_s^{S2} \\
r_{N1}\overline{N} &= (1-\beta)(1-\mu)Y_s^{N1} \\
r_{N2}\overline{N} &= (1-\beta)(1-\mu')Y_M^{N2} = \mu(1-\alpha)(1-\theta)Y_2(1-\beta)(1-\mu') \\
Y_s^{S2} + Y_s^{N1} &= Y_s = (1-\theta)Y_2 \\
r_{S2}\overline{N} + r_{N1}\overline{N} &= (1-\beta)(1-\mu)(1-\theta)Y
\end{aligned} \tag{167}$$

Furthermore, it is still the case that:

$$\begin{aligned}
r_{N1} &= G(\tau)r_{S2} \\
Y_s^{N1} &= G(\tau)Y_s^{S2}
\end{aligned} \tag{168}$$

From equations (167) and (168) above I obtain:

$$Y_s^{S2} = \frac{(1-\theta)}{1+G(\tau)}Y_2 \tag{169}$$

$$Y_s^{N1} = \frac{G(\tau)}{1+G(\tau)}(1-\theta)Y_2 \tag{170}$$

whereas the value of output produced at the remaining locations, which are not involved in intermediate s production is given by:

$$\begin{aligned}
Y_u^{S1} &= Y_u = \theta Y_2 \\
Y_M^{N2} &= \mu(1-\alpha)(1-\theta)Y_2
\end{aligned}$$

We can now analyze the main comparative static statements. I begin with the equilibrium populations of Southern cities:

$$Pop_{S1} = \frac{\beta\theta Y_2}{\xi_{1S} p_1} \tag{171}$$

$$Pop_{S2} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{S2}}{\xi_{1S} p_1} \tag{172}$$

Finding an expression for the relative size of the two southern cities during the third stage globalization:

$$\begin{aligned} \frac{Pop_{S2}}{Pop_{S1}} &= \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{S2}}{\beta\theta Y_2} \\ &= \frac{[\alpha\mu + \beta(1-\mu)]}{\beta\theta} \frac{1-\theta}{1+G(\tau)} \end{aligned} \tag{173}$$

Differentiating the last equation with respect to τ yields:

$$\frac{\partial}{\partial\tau}\left(\frac{Pop_{S2}}{Pop_{S1}}\right) = -\frac{[\alpha\mu + \beta(1-\mu)]}{\beta\theta} \frac{1-\theta}{[1+G(\tau)]^2} G'(\tau) < 0 \tag{174}$$

which implies that $\tau \downarrow \Rightarrow \frac{Pop_{S2}}{Pop_{S1}} \uparrow$ Similarly for the North I can write:

$$Pop_{N1} = \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{N1}}{\xi_{1N} p_1}$$

$$Pop_{N2} = \frac{[\mu' + \beta(1-\mu')]Y_M^{N2}}{\xi_{1N} p_1}$$

Deriving an expression for the relative size of Northern cities from the equations above we have:

$$\begin{aligned} \frac{Pop_{N2}}{Pop_{N1}} &= \frac{[\mu' + \beta(1-\mu')]}{[\alpha\mu + \beta(1-\mu)]} \frac{Y_M^{N2}}{Y_s^{N1}} \\ &= \frac{[\mu' + \beta(1-\mu')]}{[\alpha\mu + \beta(1-\mu)]} \left[1 + \frac{1}{G(\tau)}\right] \mu(1-\alpha) \end{aligned} \tag{175}$$

Differentiating the last equation yields:

$$\frac{\partial}{\partial\tau} \frac{Pop_{N2}}{Pop_{N1}} = (-1)\frac{1}{[G(\tau)]^2} G'(\tau)\mu(1-\alpha) < 0 \tag{176}$$

which implies that along the range of communication costs covered by result 9, any reduction of these communication costs is associated with an increase in the relative size of the skilled city in the North (i.e. $\tau \downarrow \Rightarrow \frac{Pop_{N2}}{Pop_{N1}} \uparrow$). Moving on to discuss the statement about urbanization in Result 9, note that I can write Y_s^{S2} as $Y_s^{S2} = f(\tau)Y_s$ with $f'(\tau) < 0$ and I can also express worldwide urban population as:

$$\begin{aligned} \text{Urban population} &= \frac{\beta\theta Y_2}{\xi_{1S} p_1} + \frac{[\alpha\mu + \beta(1-\mu)](1-\theta)Y_2 f(\tau)}{\xi_{1S} p_1} \\ &+ \frac{[\alpha\mu + \beta(1-\mu)](1-\theta)[1-f(\theta)]Y_2}{\xi_{1N} p_1} + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]Y_2}{\xi_{1N} p_1} \end{aligned} \tag{177}$$

which can be rewritten

$$\text{Urban population} = \frac{Y_2}{p_1}\left\{\frac{\beta\tau}{\xi_{1S}} + [\alpha\mu + \beta(1-\mu)](1-\theta)\left[\frac{\xi_{1S} + (\xi_{1N} - \xi_{1S})f(\tau)}{\xi_{1S}\xi_{1N}}\right]\right.$$
$$\left. + \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]}{\xi_{1N}}\right\} \tag{178}$$

Differentiating the previous equation yields:

$$\frac{\partial}{\partial\tau}\text{Urban population} = \underbrace{\frac{\partial\frac{Y_2}{p_1}}{\partial\tau}}_{<0}\{\ldots\} + \frac{Y_2}{p_1}\frac{[\alpha\mu + \beta(1-\mu)](1-\theta)}{\xi_{1S}\xi_{1N}}(\xi_{1N} - \xi_{1S})\underbrace{f'(\tau)}_{<0} < 0 \tag{179}$$

where the proof that ($\tau \downarrow \Rightarrow \frac{p_1}{Y} \downarrow \Rightarrow \frac{Y}{p_1} \uparrow \Rightarrow \frac{Y_2}{p_1} \uparrow$ (which also establishes the sign of the first partial derivative in equation 179 above) is identical to the one in Result 7. I can conclude that along the interval of communication costs covered by result 9 we have that: $\tau \downarrow \Rightarrow$ World urban population $\uparrow \Rightarrow$ World Urbanization $\uparrow$.

Unlike previous results, Result 9 also contains a statement concerning the changes in the absolute level of population for the skilled city of the North, city $N2$, which I prove below:

$$Pop_{N2} = \frac{[\mu' + \beta(1-\mu')]Y_s^{N2}}{\xi_{1N}p_1} = \frac{[\mu' + \beta(1-\mu')]\mu(1-\alpha)(1-\mu')Y_2}{\xi_{1N}p_1} \tag{180}$$

Differentiating the previous expression with respect to τ yields:

$$\frac{\partial Pop_{N2}}{\partial\tau} = \frac{[\mu' + \beta(1-\mu')]\mu(1-\alpha)(1-\mu')Y_2}{\xi_{1N}}\underbrace{\frac{\partial}{\partial\tau}\left(\frac{Y_2}{p_1}\right)}_{<0} < 0 \tag{181}$$

which establishes that reductions in communication costs in the third stage of globalization lead to absolute growth in the size of the Northern skilled city (i.e. $\frac{\partial Pop_{N2}}{\partial\tau} < 0$ which is equivalent to $\tau \downarrow \Rightarrow Pop_{N2} \uparrow$).

Result 9 also implies that along the third stage of globalization we observe a stop of skill divergence across cities, within countries, in both North and South. This is shown below:

$$\frac{H_{S1}}{L_{S1}} = 0$$
$$\frac{H_{S2}}{L_{S2}} = \frac{\alpha\mu}{\beta(1-\mu)}$$
$$\frac{H_{N1}}{L_{N1}} = \frac{\alpha\mu}{\beta(1-\mu)}$$
$$\frac{H_{N2}}{L_{N2}} = \frac{\mu'}{\beta(1-\mu')}$$
$$\frac{\partial}{\partial\tau}\left(\frac{H_{S2}}{L_{S2}} - \frac{H_{S1}}{L_{S1}}\right) = 0$$
$$\frac{\partial}{\partial\tau}\left(\frac{H_{N2}}{L_{N2}} - \frac{H_{N1}}{L_{N1}}\right) = 0$$

Finally, analyzing the movements in the price of land triggered by improving communications:

$$r_{S1}\overline{N} = (1-\beta)\theta Y_2 \tag{182}$$

$$r_{S2}\overline{N} = (1-\beta)(1-\mu)Y_s^{S2} \tag{183}$$

Computing the ratio of the rental rates of the two southern locations:

$$\begin{aligned}\frac{r_{S2}}{r_{S1}} &= \frac{(1-\beta)(1-\mu)\frac{1-\theta}{1+G(\tau)}Y_2}{(1-\beta)\theta Y_2}\\ &= \frac{1-\theta}{\theta}\frac{1-\mu}{1+G(\tau)}\end{aligned} \tag{184}$$

Differentiating the last equation yields:

$$\frac{\partial}{\partial\tau}\left(\frac{r_{S2}}{r_{S1}}\right) = -\frac{1-\theta}{\theta}\frac{1-\mu}{[1+G(\tau)]^2}G'(\tau) < 0 \tag{185}$$

which implies that $\tau \downarrow \Rightarrow \frac{r_{S2}}{r_{S1}} \uparrow$. Shifting focus to the North we have:

$$\begin{aligned}r_{N1}\overline{N} &= (1-\beta)(1-\mu)Y_s^{N1}\\ &= (1-\beta)(1-\mu)(1-\theta)\frac{G(\tau)}{1+G(\tau)}Y_2\end{aligned} \tag{186}$$

$$\begin{aligned}r_{N2} &= (1-\beta)(1-\mu')Y_M^{N2}\\ &= (1-\beta)(1-\mu')\mu(1-\alpha)(1-\theta)Y_2\end{aligned} \tag{187}$$

Computing the ratio of rental rates for the two Northern cities yields:

$$\frac{r_{N2}}{r_{N1}} = \frac{1+G(\tau)}{G(\tau)}\frac{\mu(1-\alpha)(1-\mu')}{1-\mu} \tag{188}$$

differentiating with respect to τ

$$\frac{\partial}{\partial\tau}\left(\frac{r_{N2}}{r_{N1}}\right) = -\frac{\mu(1-\alpha)(1-\mu')}{1-\mu}\frac{G'(\tau)}{[G(\tau)]^2} < 0 \tag{189}$$

which yields the conclusion that $\tau \downarrow \Rightarrow \frac{r_{N2}}{r_{N1}} \uparrow$ which completes the proof of Result 9. A similar approach can be used to show that along this stage of globlization, rental rates for land rise in absolute terms in three cities - $S1$,$S2$ and $N2$.

Result 10 Along the interval of communication costs given by

$$\underbrace{\frac{\left[\frac{\theta}{(1-\mu)(1-\theta)}\right]^{\frac{(1-\beta)(1-\mu)}{\mu(1-\alpha)}} A^{\frac{\beta(1-\mu)}{\mu(1-\alpha)}}\left(\frac{\xi_{1N}}{\xi_{1S}}\right)^{\frac{\alpha}{1-\alpha}}}{\left[1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}\right]^{\frac{(1-\mu)(1-\theta)}{\mu(1-\alpha)}}}}_{\tau^*} < \tau < T_{ovt} \tag{190}$$

the unique stable equilibrium involves activity s being produced in locations $\{S2, N1\}$, u being produced in location $S1$ in the South and location $N1$ in the North while management services (M) are produced only in $N2$. Moreover, along this interval, any reduction in communication costs is associated with increased urbanization and worldwide GDP, faster increases in Southern GDP, growth in the relative size of advanced cities in both countries, divergence in real estate prices across cities in both North and South, with relatively skilled cities favored, as well as the de-skilling of city $N1$ and skill polarization across Northern cities.

Proof: As in the previous results I focus on the comparative static statements. I again need to establish some intermediate results.

Result 10.1 For $\tau^* < \tau < T_{spec2}$ a reduction in communication costs is associated with a decline in the relative price of the urban good (i.e. $\frac{\partial}{\partial \tau}\left(\frac{p_2}{p_1}\right) > 0$)

Proof: Similar to Result 7.1, 8.1, 9.1.

Result 10.2 For $\tau^* < \tau < T_{spec2}$ a reduction in international communication costs is associated with an increase in world output.

Proof: Similar to Result 7.2, 8.2, 9.2.

Result 10.3 For $\tau^* < \tau < T_{spec2}$ any reduction in international communication costs is associated with an increase in relative expenditure on the urban good (i.e. $\frac{\partial \frac{Y_2}{Y_1}}{\partial \tau} < 0$)

Proof: Similar to Result 7.3, 8.3, 9.3

I focus on the statements concerning urbanization and the relative performance of locations within countries. Along the interval of communication costs covered by Result 10 stable equilibria are governed by the following key equations:

$$c_{S1}(u) = c_{N1}(u) = p_u$$

$$c_{S2}(s) = c_{N1}(s) = p_s$$

$$c_{N2}(M) = p_M$$

Making use of the above equations, stable equilibria in the fourth stage of globalization can be characterized by the following system of equations:

$$Y_u^{S1} + Y_u^{N1} = Y_u \tag{191}$$

$$Y_s^{S2} + Y_s^{N1} = Y_s \tag{192}$$

$$r_{N1} = \left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}} r_{S1} \tag{193}$$

$$r_{N1} = G(\tau) r_{S2} \tag{194}$$

$$r_{S2}\overline{N} = (1-\beta)(1-\mu)Y_s^{S2} \tag{195}$$

$$r_{N1}\overline{N} = (1-\beta)(1-\mu)Y_s^{N1} + (1-\beta)Y_u^{N1} \tag{196}$$

$$r_{S1}\overline{N} = (1-\beta)Y_u^{S1} \tag{197}$$

In the remainder of the proof of Result 10 I proceed analogously with the proofs of results $7-9$. I first solve the system of equations defined by equations (191) to (197) in order to find expressions for the value of output produced at each location:

$$Y_u^{S1} = \frac{[\theta + (1-\theta)(1-\mu)]}{1 + \left[1 + \frac{1}{G(\tau)}\right]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} Y_2 \tag{198}$$

$$Y_u^{N1} = \frac{\theta\left[1 + \frac{1}{G(\tau)}\right]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}} - (1-\theta)(1-\mu)}{1 + \left[1 + \frac{1}{G(\tau)}\right]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} Y_2 \tag{199}$$

$$Y_s^{S2} = \frac{\theta + (1-\mu)(1-\theta)}{1-\mu} \frac{\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}{G(\tau) + [1 + G(\tau)]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} Y_2 \tag{200}$$

$$Y_s^{N1} = \left\{ (1-\theta) \frac{G(\tau)\left[1 + \left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}\right]}{G(\tau) + [1 + G(\tau)]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} - \frac{\theta}{1-\mu} \frac{\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}{G(\tau) + [1 + G(\tau)]\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} \right\} Y_2 \tag{201}$$

Noting the I can write Y_s^{S2} in compact form as $Y_s^{S2} = f(\tau)Y_s$ with $f'(\tau) < 0$ I rewrite the expressions of the output produced at each location as follows:

$$Y_s^{S2} = f(\tau)Y_s \tag{202}$$

$$Y_s^{N1} = [1 - f(\tau)]Y_s \tag{203}$$

$$Y_u^{S1} = \frac{1 + \frac{1-\theta}{\theta}(1-\mu)[1 - f(\tau)]}{1 + \left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} Y_u \tag{204}$$

$$Y_u^{N1} = \frac{\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}} - \frac{1-\theta}{\theta}(1-\mu)[1 - f(\tau)]}{1 + \left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}} Y_u \tag{205}$$

With the above notation I proceed to analyze the statements of Result 10. I first derive expressions for the equilibrium populations of various locations:

$$Pop_{S2} = \frac{[\alpha\mu + \beta(1-\mu)]f(\tau)Y_s]}{\xi_{1S}p_1} = \frac{[\alpha\mu + \beta(1-\mu)]f(\tau)(1-\theta)Y_2]}{\xi_{1S}p_1} \tag{206}$$

$$Pop_{S1} = \frac{\beta Y_u^{S1}}{\xi_{1S}p_1} = \frac{\beta}{\xi_{1S}p_1}\frac{1+\frac{1-\theta}{\theta}(1-\mu)[1-f(\tau)]}{1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}\theta Y_2 \tag{207}$$

Computing the relative size of Southern cities in equilibrium:

$$\frac{Pop_{S2}}{Pop_{S1}} = \frac{[\alpha\mu + \beta(1-\mu)]}{\beta}\left[1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}\right]\frac{(1-\theta)f(\tau)}{\theta+(1-\theta)(1-\mu)[1-f(\tau)]} \tag{208}$$

Noting that $f'(\tau) < 0$ it is straightforward to see that differentiating the expression above with respect to τ leads to $\frac{\partial}{\partial\tau}\left(\frac{Pop_{S2}}{Pop_{S1}}\right) < 0$ which establishes that reductions in communication costs are associated with increases in the size of the skilled city in the South along the fourth stage of globalization. Moving the discussion to the North:

$$\begin{aligned} Pop_{N1} = & \frac{\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}} - \frac{1-\theta}{\theta}(1-\mu)[1-f(\tau)]}{1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}\frac{\beta Y_u}{\xi_{1N}p_1} \\ & + [1-f(\tau)]\frac{Y_s}{\xi_{1N}p_1}[\alpha\mu + \beta(1-\mu)] \end{aligned} \tag{209}$$

$$Pop_{N2} = \frac{\mu(1-\alpha)(1-\theta)Y_2[\mu' + \beta(1-\mu')]}{\xi_{1N}p_1} \tag{210}$$

Computing the relative size of Northern cities in equilibrium:

$$\frac{Pop_{N2}}{Pop_{N1}} = \frac{\mu(1-\alpha)(1-\theta)[\mu' + \beta(1-\mu')]}{CT_0\beta\theta + [1-f(\tau)](1-\theta)\left\{\beta(1-\mu)+\alpha\mu - \frac{\beta(1-\mu)}{1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}\right\}} \tag{211}$$

where CT_0 is a constant term that collects parameters. From the expression above it is again straightforward to see that $\frac{\partial}{\partial\tau}\left(\frac{Pop_{N2}}{Pop_{N1}}\right) < 0$ which implies that along the fourth stage of globalization reductions in communication costs are associated with increases in the relative size of the skilled city in the North (i.e. $\tau \downarrow \Rightarrow \frac{Pop_{N2}}{Pop_{N1}} \uparrow$)

Moving to worldwide urbanization, in equilibrium we have that:

$$\begin{aligned} \text{Urban Population} = & \frac{\beta Y_u^{S1}}{\xi_{1S}p_1} + \frac{\beta Y_u^{N1}}{\xi_{1N}p_1} + \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{S2}}{\xi_{1S}p_1} \\ & + \frac{[\alpha\mu + \beta(1-\mu)]Y_s^{N1}}{\xi_{1N}p_1} + \frac{[\mu' + \beta(1-\mu')]Y_M^{N2}}{\xi_{1N}p_1} \end{aligned} \tag{212}$$

Substituting for Y_u^{S1}, Y_s^{S2}, Y_u^{N1}, Y_s^{N1}, Y_M^{N2} above and collecting terms yields the expression:

$$\text{Urban Population} = \frac{Y_2}{p_1}\left\{CT_1 + f(\tau)(1-\theta)\left(\frac{1}{\xi_{1S}} - \frac{1}{\xi_{1N}}\right)\left[\alpha\mu + \beta(1-\mu) - \frac{\beta(1-\mu)}{1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}\right]\right\} \tag{213}$$

Differentiating the previous equation yields:

$$\frac{\partial \text{Urban Population}}{\partial \tau} = \underbrace{\frac{\partial}{\partial \tau}\left(\frac{Y_2}{p_1}\right)}_{<0}\{\ldots\}$$

$$+\frac{Y_2}{p_1}\underbrace{f'(\tau)}_{<0}(1-\theta)\left(\frac{1}{\xi_{1S}}-\frac{1}{\xi_{1N}}\right)\left\{\alpha\mu+\beta(1-\mu)-\frac{\beta(1-\mu)}{1+\left(\frac{A\xi_{1S}}{\xi_{1N}}\right)^{\frac{\beta}{1-\beta}}}\right\}<0 \tag{214}$$

Which establishes that reductions of communication costs are accompanied by increasing worldwide urbanization along the fourth stage of globalization.

The proofs concerning the presence of skill polarization across cities in the North (with city $N1$ actually experiencing de-skilling), as well as continued land price divergence across locations in both North and South are similar to the ones of previous results and are omitted. Furthermore, it can be shown that along the fourth stage of globalization, reductions in communication costs are guaranteed to be accompanied by growth in the levels of population in cities $S2$ and $N2$, as well as their respective absolute rental rates (proofs available on request).

Result 11 Along the interval of communication costs given by

$$1<\tau<\tau^* \tag{215}$$

the unique stable equilibrium involves activity s being produced in the advanced Southern city $S2$, u being produced only in locations $S1$ and $N1$, while management services (M) are produced only in $N2$. Moreover, along this interval, any reduction in communication costs does not generate any spatial reallocation of activities across cities, such that divergence in skill shares and land prices across cities cease. However, urbanization continues, and reductions in communication costs are associated with proportionate growth in all cities (i.e. the relative size and land prices between any two cities remain constant).

Proof: Similar to Results $7-10$ above. The configuration of the world economy reaches a "costless communication" steady state, where there are no further reallocation of market share in any sector across locations, and as such the relative size of cities, their relative rental rates and their skill shares remain constant. However, reductions in communication costs still affect the urban-rural margin, and as a result urbanization continues, and the world economy continues to grow. However all cities grow at the same rate.

Results $7-11$ jointly imply that the statements contained in propositions $2-6$ in the main body of the paper are correct (proof of these results is equivalent to joint proof of propositions $2-6$), and also establish that stages 1 to 5 discussed in the main text offer a correct description of the evolution of worldwide economic geography as international communication costs decline.

NOT FOR PUBLICATION

Appendix C: Robustness and Generality of Results

In this section I briefly discuss the robustness of the predictions of my theory to changes in modelling specification and assumptions. In particular I stress which of the model's parametric restrictions (outlined in Section 3.3) are crucial for the results obtained and which can be relaxed without notable changes to the predictions of the model.

Among the restrictions contained within Assumptions 1 to 6, only Assumptions 2, 3 and 5 are essential for the central results derived in sections 3 and 4. Thus, for the broad predictions of the model to come to pass, I require that the North is the only country where production of management is feasible, that the management services sector is subject to agglomeration economies that are sufficiently strong to encourage the clustering of the entire sector in only one city, and that the productive conditions in the two countries are such that below a certain threshold of communication costs the South becomes competitive in skilled manufacturing. If these assumptions are met the model delivers the result that for some interval of international communication costs, reductions in communication costs are associated with increases in urbanization, North-South convergence and divergence between cities within countries (in terms of population, land prices and/or skill shares).

However, some of the more detailed predictions of the model also depend on the other parametric restrictions. For instance, the theory predicts persistent divergence among Southern cities along the entire path of international economic integration. This result hinges on Assumption 4 which ensures that infrastructure is sufficiently important for skilled manufacturing that the infrastructure scarce Southern location $S1$ never becomes a suitable location for this activity. Should this assumption be relaxed, then a phase of urban divergence across Southern locations of the type described above would be followed by a phase of urban convergence when the backward Southern city also begins to attract skilled manufacturing. It is important to note that relaxing Assumption 4 is likely to make the urban divergence results in the North stronger, as any relative increase in the production possibilities of the South (the elimination of a constraint on city $S1$ represents such an increase) expands the scope for it to capture a greater proportion of global value chains, and as a result increases the vulnerability of the unskilled Northern city to Southern competition.

The remaining parametric restrictions, Assumption 1 and Assumption 6 are imposed in order to improve tractability (Assumption 1) and keep the analysis parsimonious (Assumption 6). Relaxing the latter assumption is straightforward and can be shown to have no impact on the main results reported in the previous two sections. Assumption 1 may also be relaxed in an expanded framework. Such a setup would however lose analytical tractability.

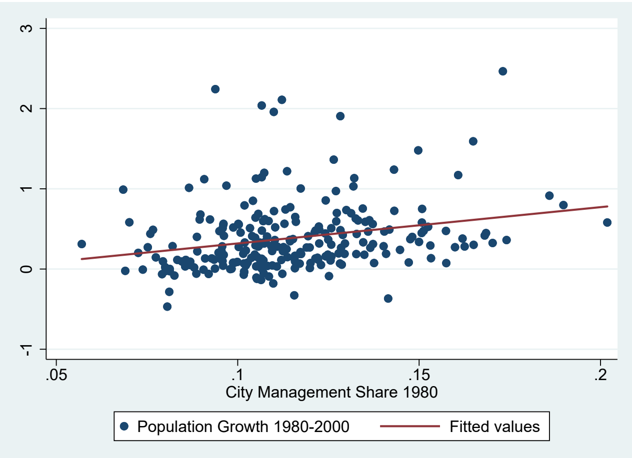
Among the other features of the model, one that is important in underpinning our urbanization growth result (though not our urban divergence results) is the greater than unity elasticity of substitution between the traditional and the urban goods in consumption. This assumption represents a simple way of embedding into the model the realistic feature: as globalization and development proceed, a greater fraction of worldwide expenditure is spent on urban goods. An alternative way of implementing the same feature would have been the introduction of non-homothetic preferences. With non-homothetic preferences and the designation of the urban good as the "advanced good" globalization leads to an increase in the expenditure share of urban goods because it increases income levels.

Finally, while in this paper I have focused on the role of communication technologies, the theory is amenable to substantial generalization. Thus, under the condition that some essential assumptions of the model are maintained (i.e. the ranking of sectors by skill intensity and by the strength of agglomeration/localization economies match or are strongly positively correlated; the North has comparative advantage in the production of skill intensive activities) any mechanism that leads to the relocation of some "middle skill" activities from the North (where they represent the least skilled pre-globalization activities) to the South (where they in turn represent the most skilled activities), can produce similar results. Alternative mechanisms that can produce the type of North-South relocation of production stages present in my model include North-South technological transfer, North-South capital mobility, FDI or Southern TFP growth due to institutional reforms.

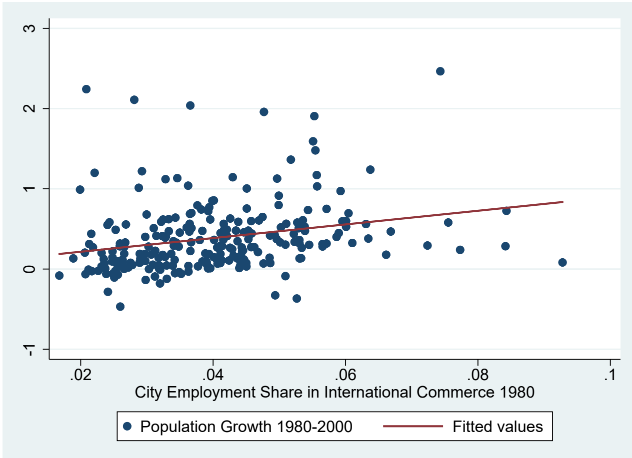
Appendix D: Specialization in Management (or International Commerce) and Urban Success in the North

My model explains the divergence of urban fortunes in developed countries by the specialization of skill abundant cities in management and other activities that stand to benefit from greater international economic integration. As communication costs decline, all developed world locations become relatively less attractive for skilled manufacturing activities. However, by specializing in skill-intensive services (such as management), in which industrialized nations maintain an overwhelming comparative advantage, the skilled cities of the global North benefit from a compensating force: the ability to sell these advanced services to a bigger and more efficient world economy.

In this section I provide some suggestive evidence in support of this mechanism. Pane a of Figure 8 shows the relationship between initial specialization in management (in the year 1980) and subsequent city growth across a panel of 239 US metropolitan areas[32]. The figure reveals a strong (and statistically significant) positive association, which is consistent with the mechanism proposed by the model.



(a) Specialization in Management and City Growth - US



(b) Specialization in "International Commerce" and City Growth - US

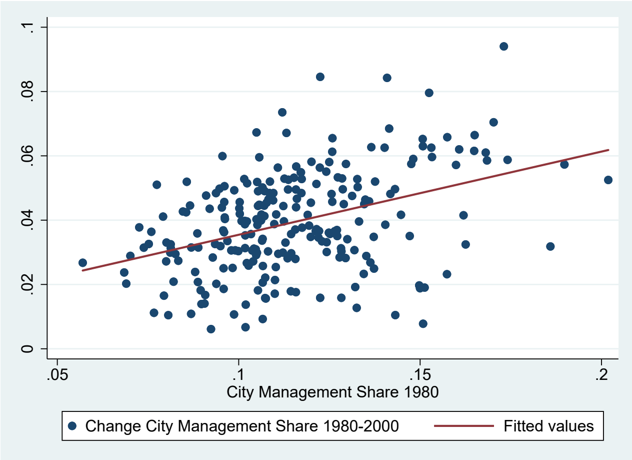
Figure 8: Economic Specialization and Urban Divergence

Notes: Pane a of the figure shows the relationship between initial (year 1980) specialization in management and subsequent (1980 to 2000) urban growth across US cities. Specialization in management is defined as the share of each city's population whose occupations are defined as "Managerial and Professional Specialty Occupations" according to a modified version of the 1990 Census Bureau occupational classification scheme. Pane b of the figure shows the relationship between initial (year 1980) specialization in "international commerce" and subsequent (1980 to 2000) urban growth across US cities. Specialization in "international commerce" is defined as the share of each city's population whose sectoral affiliation as per the 1990 Census Bureau industrial classification scheme is listed as "Finance, Insurance and Real Estate", "Computer and Data Processing Services", "Business Services", "Research, development, and testing services" or "Management and public relations services". Data is obtained from the 5% samples of the 1980, 1990 and 2000 US Censuses available via IPUMS. Our baseline sample contains 239 US metropolitan areas.

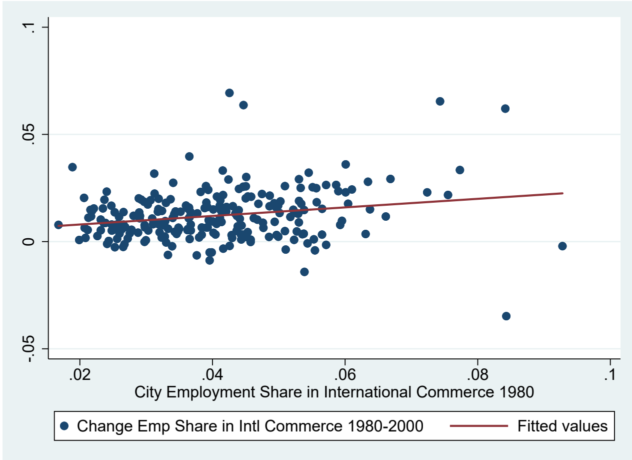
Pane b of Figure 8 undertakes a similar exercise by relating city growth to initial (year 1980) specialization

[32] Specialization in management is defined as the share of each city's population whose occupations are defined as "Managerial and Professional Specialty Occupations" according to a modified version of the 1990 Census Bureau occupational classification scheme. Results are robust to alternative (narrower) definitions of specialization in management. Additional results based on these alternative definitions are available on request.

in "international commerce"(taken to mean activities such as finance, insurance and real estate; R&D and management). Again, a strong positive association is observed, which provides further support for the claim that specialization in skilled services played a role in urban growth.



(a) Deepening Specialization in Management - US



(b) Deepening Specialization in "International Commerce" - US

Figure 9: Contribution of Management/ "International Commerce"to Urban Growth

Notes: Pane a of the figure shows the relationship between initial (year 1980) specialization in management and subsequent (1980 to 2000) change in the extent of specialization in management. Specialization in management is defined as the share of each city's population whose occupations are defined as "Managerial and Professional Specialty Occupations" according to a modified version of the 1990 Census Bureau occupational classification scheme. Pane b of the figure shows the relationship between initial (year 1980) specialization in "international commerce"and subsequent (1980 to 2000) change in the extent of specialization in "international commerce"across US cities. Specialization in "international commerce"is defined as the share of each city's population whose sectoral affiliation as per the 1990 Census Bureau industrial classification scheme is listed as "Finance, Insurance and Real Estate", "Computer and Data Processing Services", "Business Services", "Research, development, and testing services" or "Management and public relations services". Data is obtained from the 5% samples of the 1980, 1990 and 2000 US Censuses available via IPUMS. Our baseline sample contains 239 US metropolitan areas.

Aside from predicting that Northern cities specialized in skilled services (such as management or international commerce) grow more rapidly than cities specialized in other activities, my model also predicts that these skilled activities are the main drivers of that growth. In what follows, I aim to provide some empirical support for this prediction. In particular, I relate initial specialization in skilled services to subsequent changes in the extent to which cities are specialized in these activities. Intuitively, if we can show that the (growing) cities that are initially specialized in management tend to deepen this specialization over time, this would imply that the management (or "international commerce") sector in these cities grows even faster than the cities as a whole and thus represents an important driver of urban growth.

Figure 9 displays the results of this exercise. Pane a shows the relationship between US cities initial (year 1980) specialization in management and the change in the share of the population employed in management between 1980 and 2000. A strong positive relationship is observed, which is consistent with the view that US cities initially specialized in management grew faster over the period 1980 to 2000 partially because of the rapid growth of the management sector itself.

Pane a of Figure 9 displays the results of the same exercise when the variable of interest is specialization in "international commerce"(defined as activities including finance, management and R&D). Again a positive (albeit weaker) and statistically significant relationship is found between initial specialization in "international commerce" and the change in the proportion of a city's population employed in "international commerce" activities. This is consistent with the view that US cities initially specialized in "international commerce" grew faster over the period 1980 to 2000 partially because of the rapid growth of "international commerce" activities themselves.