Globalization and the Smart City

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Abstract

The last five decades have witnessed a rapid acceleration of processes that are habitually associated with the notion of globalization, such as the growth in international trade and international financial flows, the intensification of technology transfers and, to some extent, the growth in international labor mobility. This acceleration of globalization has occured contemporaneously with a rapid acceleration of urbanization, particularly in developing countries. Recent research in urban economics and economic geography has uncovered some further interesting developments: at the same time as cross-country economic geography has experienced some rebalancing, with some major developing countries catching up to rich countries, the within country economic geography of many countries has grown more uneven, with succesful cities and regions capturing an increasing share of their countries'populations and output. Moreover, human capital seems to have become an important driver of within-country economic geography, with "educated"cities scoring higher on various measures of urban success than their less skilled counterparts. The present paper will propose a theory that suggests that the recent onslaught of globalization and the latest shifts in economic geography are closely related in that they are jointly caused by the fall of transportation and communication costs. Some suggestive evidence supporting the theory is also discussed.

1 Introduction

The location of economic activity across countries has long captured the attention of economists. In contrast, the analysis of the geographic distribution of economic activity within countries has, until recently, received relatively less interest. However, in the last two decades, research has uncovered a series of important developments in within country economic geography.

In particular, evidence suggests that just as economic activity has tended to become more dispersed across countries, with major developing countries like China and India beginning to catch-up relative to industrialized countries, the distribution of economic activity within most countries has become more concentrated. This within country concentration has occured along two main dimensions.

Firstly and most saliently, the pace of urbanization has accelerated rapidly, particularly in developing countries. In 1950 only around 30% of the world's population was urban,whereas by 2008 more than half of the world's people lived in cities. This trend is expected to continue, with most projections indicating that the world urbanization rate will exceed 65% by 2050.

Secondly, the economic geography of many countries has become "lumpier", with succesful cities and regions amassing an increasing share of their countries' economic output, population and physical and human capital whilst less succesful cities and regions seem to have entered a period of stagnation or even decline.[1]

Some of the most interesting findings of this recent literature concern the substantial role played by human capital as a driver of within country economic geography. A series of studies carried out primarily for developed countries have found that the initial skill endowment of a city is a strong predictor of future city growth across a number of dimensions such as population and employment. Cities with a higher initial level of education also seem to score better than their less skilled counterparts across other measures of urban success such as real estate price growth and crime rates.

Moreover, a phenomenon of skill polarization across cities has been documented for a number of countries [2], with skilled cities not only growing faster than their low-skilled counterparts, but also increasing their relative skill advantage over low-skilled cities. While skill share differentials across cities remain relatively small and the trend towards skill divergence documented in the literature has so far had modest proportions, Berry and Glaeser (2005) note that "segregation by skill may become more important if this trend continues".[3]

Thus we seem to live in a world in which cross-coutry economic convergence has been often accompanied by divergence in within country economic geography, with skill endowments seemingly playing an important role in determining which cities or regions are economically successful and which are not. These that the aforementioned shifts in economic geography have occured contemporaneously with an accelerated trend towards greater international economic integration (globalization) that has emerged since the 1960s, with trade, international financial flows, international technology transfer and international labor mobility all growing rapidly.

In this paper I argue that the coincidence of more rapid globalization and

[1]For a discussion of these interesting concurring trends see van der Ploeg and Poelhekke (2008) and McCann(2007)

[2]The seminal study documenting this pattern is Berry and Glaeser (2005) for the US. A similar result is obtained by Poelhekke (2013) for Germany

[3]Note that the finding of skill divergence across space seems to be less robust to specifications of alternative units of geographical disaggregation and when looking at different countries. Thus Sudekum (2009), undertaking a similar type of analysis for German regions finds a result of skill convergence across regions. Similarly Queiroz and Golgher (2008) find mixed results when analyzing the evolution of skill disparities across Brazilian municipalities: convergence in skill levels when analyzing the entire sample of Brazilian municipalities, but divergence in skill levels when restricting attention to municipalities with more than 100000 inhabitants.

the aforementioned shifts in economic geography has not occured by chance but reflects deep structural and technological forces that have driven both trends. In particular I argue that the reduction in communication and transportation costs that have been important drivers of increased international economic integration have also shaped the observed shifts in economic geography both within and across countries.

The main contribution of the paper is a model that rigorously formulates the hypothesis that a fall in communication and transportation costs can help us jointly account for the urban economics stylized facts mentioned above - increased worldwide urbanization, faster growth of skilled cities, skill divergence across cities and faster real estate price growth in skilled cities for both rich and poor countries. The proposed theory will take the notion of global supply chains seriously and will suggest that the technological forces of globalization, i.e. falling communication and transportation costs, have led to reallocations of activities along global supply chains across and within countries in a way that has largely favoured skilled cities in both North and South. These reallocations of activities are shown to have interesting economic geography implications that, under some conditions, qualitatively match the patterns of urban outcomes observed in the data.

The proposed model makes several additions to the existing literature. Firstly it offers one of the first attempts at a theoretical framework that jointly explains urbanization, the pattern of differential growth of cities with different skill levels as well as the trend of skill divergence across cities. Most of the papers that have addressed these issues in the existing literature have focused on a subset of the empirical regularities discussed above.

Secondly, the paper adds to the literature analyzing the effects of international economic integration (globalization) on the distribution of economic activity within countries. Most of the existing studies in this literature have focused almost exclusively on trade openess as a channel through which globalization could affect countries' economic geographies. In contrast, this study considers channels other than trade costs, such as communication costs and intermediate goods trade, which can cause or facilitate some of the observed developments in countries' urban systems.

Further, the theory provided below is the first that explicitly aims to jointly explain the observed patterns of urban outcomes for both developing and developed countries. In so doing, this paper highlights the possibility that some of the forces identified in the international trade literature as potentially responsible for the evolution of skill premia across countries may also be responsible for driving the observed shifts in within-country economic geography.

Finally, the theoretical framework presented herein introduces into the urban economics literature some ideas that are already quite popular in geography, urban studies, sociology and other social sciences. As already mentioned, the model is based on the idea that the geographical fragmentation (both national and international) of global supply chains is an important driver of economic geography at various levels of disaggregation. Thus, the analysis naturally lends itself to an interpretation of the following type: the geographical allocation

of activities along the global supply chain generates a global urban hierarchy in which large, skilled and technologically advanced cities play a central role. Moreover, shifts in countries' market access, endowments of factors of production or technology (either exogenous or induced by the forces of globalization) can cause shifts in this urban hierarchy. This feature of the model is not only interesting because it "translates"some ideas from other fields into a formal economic model,but also because it serves to illustrate an interesting theoretical possibility: urban "overtaking". This is the phenomenon whereby it becomes possible for cities in the developing world to "overtake"developed world cities along the global supply chain. This theoretical possibility is intriguing given the recent rise of developing world cities.

The rest of this paper is organized as follows. Section 2 will briefly discuss strands of related literature, with a focus on the theoretical frameworks that have been suggested to account for the observed patterns in urban outcomes. Section 3 will introduce the model and analyze its implications. Section 4 will discuss some suggestive empirical evidence that provides some support for the mechanism of city growth highlighted by the theory. Section 5 concludes.

2 Related Literature

In this section we will briefly review some of the literature related to the current paper, with an emphasis on the theoretical frameworks put forward as potential explanations for the urban developments of interest.

Firstly and perhaps most importantly, the current paper is related to the urban economics literature that documents and attempts to provide an account for the divergent urban outcomes of skilled and unskilled cities that we also seek to explain in this paper, namely the faster growth of skilled cities and the phenomenon of skill polarization across cities. Perhaps the most comprehensive study of the differential growth of skilled and unskilled cities is Glaeser and Saiz (2004), which analyzes a sample of 318 US metropolitan areas for the period 1980 to 2000 and finds that a 1 percentage point increase in the share of adult population with a bachelor's degree is associated with an increase in the decadal growth rate of about half of one percent. The authors put forward three potential explanations for the observed empirical regularity, namely consumer amenities, knowledge spillovers and skill-technology adaptation linkages, i.e. namely skilled cities are more adaptable to new technologies.[4] They also find evidence that suggests that productivity spillovers are the main drivers of the faster (population) growth of skilled cities and interpret the evidence as being particularly consistent with the hypothesis that skilled cities thrive because they are better equipped to adapt to technological changes.

Shapiro (2003) undertakes a similar type of analysis but focuses on employment growth. He also finds that productivity spillovers account for more of the differential growth of skilled cities than consumption amenities, although

[4]The later two explanations are termed "The Information City"and the "Reinvention City"in the terminology of Glaeser and Saiz (2004)

the latter are also important. In a theoretical paper, Glaeser and Ponzetto (2010) offer a model that formalizes the idea that skilled cities will tend to grow faster because of their greater ability to adapt to the flight of manufacturing induced by technical progress (a scenario similar to the "Reinvention City"story in Glaeser and Saiz (2004)).

Other, mostly empirical, papers that belong to this literature and document the more rapid growth of skilled cities include Glaeser (1994), Glaeser, Scheinkman and Shleifer (1995), Simon and Nardinelli (2002), Black and Henderson (1999), De la Garza (2008) for the US, Nardinelli and Simon (1996) for the UK, Poelhekke (2007) for Germany, Bosker and Marlet (2012) for the EU as a whole, Da Mata.,Deichmann, Henderson, Lall and Wang (2007) for Brazil and Anderson and Ge (2004) for China. [5]

Regarding the finding of skill polarization across cities, the seminal paper is Berry and Glaeser (2005). Again, using a sample of 318 metropolitan areas in the US, they find that a 1 percent increase in the skill share of a city in 1990 is associated with a 1.13 percentage point increase in the share of adults with college degrees in 2000. Berry and Glaeser (2005) also offer a production side theory based on entrepreneurship that can account for the empirical findings. Poelhekke (2006) finds similar results regarding cross-city skill divergence but argues that the existing evidence is most consistent with an amenity-based explanation. The model of Glaeser and Ponzetto (2010)[6] also predicts skill divergence across metropolitan areas while Liao (2010)[7] sets out a model based on outsourcing that offers the same prediction.

Secondly, the current paper is related to the literature on urbanization and structural transformation. While the model proposed herein relies on changes in the patterns of comparative advantage and international specialization to produce changes in the industrial structure of national economies and, ultimately, changes in their economic geography, much of the previous literature relies on structural transformation to account for the changing composition of national economies and the resulting shifts in economic geography.

The macroeconomics literature proposes two alternative explanations for structural transformation. The first explanation involves the presence of uneven productivity growth in a multisector economy with inelastic demand across sectors. Thus, the most common framework in this strand of literature explains the shift of value added and employment out of agriculture and into manufacturing

[5] De La Garza (2008) and Poelhekke argue that many of the estimates of the effect of the skill share on city growth found in the literature suffer from upward bias. After correcting for the bias, these authors still find significant effects on the skill share on subsequent city growth, although the magnitude of the effects is substantially reduced.

[6] To the best of my knowledge, Glaeser and Ponzetto (2010) offer the only model that can jointly account for both empirical regularities that we aim to explain in the current paper. Their model is based on technological progress in transport and communications and ignores any international considerations, while our model focuses on international reallocations of economic activity and their effect on within country economic geography

[7] While our own model can also be interpreted as a model of offshoring, there are substantial differences with the framework in Liao (2009). Mainly, the framework of Liao(2010) does not address the finding of faster growth among skilled cities and ignores any international considerations.

by the more rapid productivity gains recorded in agriculture coupled with the limited substitutability between agriculture and manufacturing. Papers relying on this type of theoretical framework include Baumol (1967), Ngai and Pissarides (2007) and Rogerson (2008). A few papers, such as Michaels, Redding and Rauch (2011, 2012, 2013), further explore the potential economic geography implications (mainly urbanization) of structural transformation generated by this type of mechanism.

The second class of theoretical models explaining structural transformation is based on nonhomothetic preferences in which the relative share of the less advanced sector, in general agriculture, declines with real income. This type of model features in papers such as Echevarria (1997), Gollin, Parente and Rogerson (2002) and Matsuyama (2002). Papers focused on the economic geography implications (again mainly focused on urbanization) of structural transformation that incorporate this second theoretical mechanism include Jedwab (2013) and Gollin, Jedwab and Vollrath (2013).

The third strand of literature that is related to the present work is the one exploring the implications of international economic integration (globalization) on within-country economic geography. As previously noted, most of the papers in this strand of literature have restricted attention to the impact of trade openess on the location of economic activity within countries, while neglecting the other elements of globalization such as intermediate/ service trade, international factor mobility or international technology transfer.

Thus,Krugman and Livas Elizondo (1996) (building on the basic framework of Krugman (1991)) design a model with congestion costs as the source of dispersion and show that lower international trade costs foster dispersion in the country opening up to trade. They go on to argue that their model can explain the experience of Mexico after the ratification of NAFTA. Paluzie (2001) engages in a more direct extension of Krugman's (1991) model, preserving immobile factors rather than congestion costs as the source of dispersion. This is shown to be enough to completely reverse Krugman and Livas Elizondo's result: falling international trade costs foster agglomeration in the country opening up to trade. Monfort and Nicolini (2000) extend the original Krugman model to two countries and four regions confirming the essence of Paluzie's (2001) result: international trade liberalisation between countries leads to more agglomeration within each country. Finally, in a series of related papers Behrens, Gaigne, Ottaviano and Thisse (2006, 2007a, 2007b), show in a tractable model that international trading costs and intra-country transport costs can interact to determine a rich taxonomy of intra-country economic geographies.

The empirical literature mirrors the indeterminacy found in the theoretical work. According to Brulhart (2011) the empirical studies in this literature can be categorised into two main strands: one class of papers that explores the determinants of summary measures of within country spatial concentration using cross-country regressions (e.g. Egger et al (2005), Ades and Glaeser (1995), Nitsch (2006), Brulhart and Sbergami (2008), Henderson (2000)) and another strand of papers that study specific geographic reallocations within individual countries employing within country regressions (e.g. Hanson (1997,1998), Kan-

bur and Zhang (2005), Henderson and Kuncoro (1996), Pernia and Quising (2003), Sanguinetti and Volpe Martincus (2009), Redding and Sturm (2008)). The majority of cross-country studies find no significant effect of trade openness on urban concentration and regional inequality while the results of the studies in the second strand of literature are more mixed.

Finally, the current paper is related, via the type of modelling approach used, to the international trade literature that emerged from the seminal contributions of Dornbusch, Fischer and Samuelson (1977, 1982). In particular, the modelling strategy used in the present paper shares many features with the model employed by Feenstra and Hanson (1996) to explain the interesting fact that international economic integration seems to be associated with increasing skill premia in both developing and developed countries.

3 Theoretical Framework

In this section I outline a simple model that highlights some of the channels through which the forces of globalization may influence the location of economic activity both across and within countries, potentially accounting for the empirical regularities described above. The model seeks to account for the following stylized facts:

1. The pace of urbanization has accelerated significantly in the past five decades, particularly in developing countries;
2. Skilled cities have tended to display more robust population and employment growth than unskilled cities in the last few decades;
3. Skilled cities have also performed better on another important measure of urban success, real estate price growth; and
4. There has been a trend of skill polarization across cities, with cities that started out more skilled augmenting their skill advantage relative to baseline cities.

While the model presented below will emphasize the role of reduced communication costs that facilitate the remote delivery of advanced services, it is important to note that the theory allows for multiple interpretations of the specific forces that cause the link between globalization and the noted economic geography developments. This will be further clarified in the next section. The main take home message of the proposed theory is that in the presence of localized agglomeration economies or localized natural advantage, (technological) shocks to a country's market access, productivity or factor endowments will be transmitted through international trade channels and subsequently affect the location of economic activity both within and across countries. Under some assumptions about the specialization patterns of countries and the strength and nature of

localized agglomeration forces these type of mechanisms can qualitatively account for the observed patterns of urban outcomes. Section 4 of the present paper will then aim to offer some more substantitative, quantitative backing for the proposed theory.

3.1 Model Set-Up: Preliminaries

Imagine a world economy made up of two countries, denoted N (North) and S (South). Each country will be assumed to contain two cities indexed $N1$ and $N2$ (in country N) and respectively $S1$ and $S2$ (in country S) and a hinterland. The two countries will be endowed with exogenous and large populations of identical workers L_N and L_S. We will make the assumption that the populations of the two countries are sufficiently large such that, throughout our analysis, the hinterlands of either country will never become empty (i.e. no country will reach an urbanization rate of 100%).

In our model agents (workers) will be assumed to be endowed with one unit of time and will have to choose between three main career-location options: they can either stay in the hinterland and engage in a subsistence/ leisure activity, they can go to the city and work as an unskilled worker in the tradeable sector or they can become skilled by expending a fraction ϵ of their time acquiring education and then go to the city to work as a skilled worker in the tradeable sector. To reflect the presumption that the standards of living are higher in the "rich"North relative to the "poor"South we will assume that the outside option provided by the subsistence/ leisure activity is more attractive in the North than in the South. Thus if a worker in the North remains in the hinterland he achieves an utility level of u_N, while a worker in the South that remains in the southern hinterland receives utility u_S, and we will have that $u_N > u_S$. Note that we have also assumed, for simplicity, that the educational technology is the same across countries, that is workers in both countries have to expend the same fraction ϵ of their time to become educated.

Within countries, we will assume that locations are identical up to their endowment of a productive amenity which we can think of as being infrastructure.[8] We will assume that the locations in the North are ex-ante completely identical, both having an endowment $A > 1$ of the productive amenity. However, we will assume that the locations (cities) in the South are heterogenous, with the more "advanced"city $S2$ having an endowment of the productive amenity equal to that of the Northern cities, while the more "backward"city $S1$ is endowed with only one unit of the productive amenity. All locations (cities) are also assumed to be endowed with the same amount $\bar{N}$ of location specific immobile capital which we can think of as land. I also assume that workers are immobile internationally, but costlessly mobile across locations within countries.

[8]We could write the model without assuming any exogenous differences across locations within countries, with qualitatively similar results. However, such a model would be significantly more complicated and probably not analitically tractable

3.2 Model Set-Up: Production

We will assume that there is only one final good produced in the world economy, which we will also designate as the numeraire. This final good will be costlessly assembled by performing two tasks (or equilvalently by assembling two intermediate goods), with the production technology being given by:

$$Q = q_1^a q_2^{1-a} \tag{1}$$

Without loss of generality we will consider that task 1 is relatively unskilled, whereas task 2 is relatively skilled. We will further assume that the skilled task has a greater share in the production of the final good than the unskilled task, i.e. $a < \frac{1}{2}$.[9]

In turn, the intermediate tasks are performed/ produced with the following technologies:

$$q_{1cn} = (A_{cn} L_{1cn})^{\beta} N^{1-\beta} \tag{2}$$

$$q_{2cn} = \left[(A_{cn}^{\rho} H_{2cn})^{\alpha} M_{cn}^{1-\alpha}\right]^{\gamma} \left[(A_{cn} L_{2cn})^{\beta} N^{1-\beta}\right]^{1-\gamma} \tag{3}$$

where A denotes the productive amenity at the location of production, L denotes unskilled labor, H denotes skilled labor and M denotes management services, the indexes c and n denote the country and respectively the city of production, while α, β, γ and ρ are parameters, with $\alpha, \beta, \gamma < 1$ and $\rho > 1$
Management services (M), in turn, are themselves produced from the primary factors of production via the technology:

$$M_{cn} = B_{cn} (A_{cn}^{\rho} H_{Mcn})^{\gamma'} \left[(A_{cn} L_{Mcn})^{\beta} N^{1-\beta}\right]^{1-\gamma'} \tag{4}$$

where all the variables and parameters retain their meanings from above, B_{cn} is an additional productivity shifter that will be characterized below and we have that $\gamma' > \gamma$, and hence the management services intermediates represent the most skill intensive good/task produced in the world economy.
To complete the description of the productive side of the economy we will specify the location-specific productivity shifter featuring in the production function for management services:

$$B_{cn} = \xi_c F\left(\frac{M_{cn}}{M}\right) \text{ with } F'(.) > 0 \tag{5}$$

where ξ_c is a country specific productivity shifter and $F(.)$ is an increasing function of the scale of production of management services normalized by the world production of such services.

According to the above specification, the management services sector differs from the other sectors of the economy on a number of dimensions. Firstly, it

[9] The assumption that more advanced, skill intensive stages of the production process contribute disproportionately to the value of the final product is largely consistent with empirical observations.

is the only sector of the economy subject to localized agglomeration economies. Thus, as the expression above makes clear, there are learning effects in the production of management services, with a location becoming more productive in performing these management services the greater the scale of their local production.[10] This agglomeration force will tend to encourage the colocation in the producers of management services in only one city.

Secondly, the specification above induces a cross-country asymmetry in the production of management (advanced) services by introducing a country specific productivity shifter. In fact we will make our analysis even more stark by assuming that the advanced Northern country has an overwhelming productivity advantage in the management services sector, namely $\xi_N >> \xi_S$. This will be assumed to be sufficiently large such that in any equilibrium throughout our analysis the management services will be produced exclusively in the North.

The set-up outlined above embeds a series of assumptions which I will make explicit and attempt to justify in what follows. The first concerns the role of the local productive externalities. The posited specifications of the production functions imply that the local productive amenities make workers of all skill levels in all sectors more productive. However we have assumed that the productivity enhancing effect of the local productive amenity is particularly strong for skilled workers. Thus, from the assumed expressions we see that an endowment of $A > 1$ units of the local productive amenity at a particular location enhances the productivity of unskilled workers in any sector at that location by a factor of $A > 1$, but augments the productivity of skilled workers by a larger A^ρ with $\rho > 1$. As a consequence, locations with high endowments of the local productive amenity become attractive for sectors that make intensive use of skilled labor. However productive amenities will be a relevant location force only in the South, where we have heterogeneity across cities in the endowment of the productive amenity.[11][12]

A second assumption embedded in the framework outlined above concerns the density of employment in various sectors of the economy. Thus according to the assumed production technologies, the sectors of the world economy (task

[10] For mathematical convenience we performed a normalization, making the localization effect depend not on the scale of production, but on the normalized scale of production. This makes the algebra easier but has no substantive effects on our analysis.

[11] Note that we assumed that the Northern cities are completely symmetric along all dimensions

[12] The assumptions on the endowments of productive amenities coupled with the assumptions on the specifics of production in the various industries will yield us a model in which the forces of agglomeration in the North and South will be different in nature. Thus in the South there will be agglomeration in the search of the productive amenity, whereas in the North, the management services sector will agglomerate (in any stable equilibrium) in only one city, even if the two Northern cities ar ex-ante identical. We make these assumptions that lead to agglomeration forces of differing natures in the North and South largely for the sake of tractablility, and I conjecture that the qualitative source of the agglomeration force does not have any qualitative impact on the predictions of the theory. However, it is not inconceivable that the sources and nature of agglomeration forces are indeed different in developed and developing countries. The question of the sources of agglomeration economies across countries occupying different positions along global supply chains and whcih find themselves at various stages of development is in itself a very interesting one, warranting further research.

1, task 2, management services) are ranked not only by skill intensity but also by their density of employment, with more skilled sectors displaying greater density of employment. This assumption is largely borne out by the data.[13]

Another important assumption embedded in the proposed framework is that all productivity externalities, whether exogenous and generated by local productivity amenities or endogenous and generated by localization economies operate outside the boundary of the firm. This will allow us to maintain the assumption of perfect competition across all task and services markets throughout the analysis.

Finally, we have also assumed that the more advanced sector of the economy (the sector performing task 2) is also the sector that makes more intensive use of the management services/ advanced intermediate inputs. There indeed exists some evidence that sectors that make more intensive use of skill intensive intermediates in production (and the management/advanced services sector can be considered and intermediate in the production of task 2) also tend to be more skill intensive themselves. Such evidence is for instance provided by Voigtlander (2013).

Before moving on to characterising the consumption side of the economy, we conclude this section by specifying the transportation technologies available in our world economy. For the sake of tractability we will assume that both the final good and the tasks that make it up are costlessly tradeable both within and across countries. Management services, on the other hand, will be assumed to be subject to negligible "communication"costs within countries, but to significant such costs when delivered across countries. These communication costs will be modeled as standard iceberg transport costs, with $\tau > 1$ units of the management services needing to be shipped from a location within country c for one unit of such services to be delivered to a city within country c'. [14][15] Re-

[13]An analysis of input-output tables reveals that it is indeed true that more skill intensive sectors also tend to be less land intensive. This assumption is also relatively standard in the urban economics literature. For instance it is made by Glaeser and Ponzetto (2010)

[14]The reader may have noticed that the suggested framework only features tradable goods, with nontradables absent from the analysis. This is done for the sake of simplicity. Adding nontradables should not fundamentally change the predictions of the theory, with a potential exception for the implications concerning stylized fact 4. Moreover, while ignoring nontradables might seem excessive, as they represent a large fraction of modern economies, the assumptions made might be more innocous than they seem. Thus, Research by Moretti (2010, 2011, 2013) seems to suggest that the tradeable sector, though smaller, has a disproportionate influence over the location of economic activity. Moretti shows that each job added in the tradeable sector in a local labor market leads to the addition of more than one job in the nontradeable sector which indicates the presence of a local multiplier.In a sense, it seems that the location of the tradeable sector seems to determine the general patterns of economic geography, with the nontradeable sector largely "following"the nontradeable sector.

[15]It may also seem somewhat arbitary to assume away transport costs for goods but consider communication costs for (management) services.This is clearly a simplification, performed mostly for the sake of tractability. There are many reasons why we think there has been a shift of production chains towards developing countries: lower transportation costs, lower trade costs, N-S technological catch-up, decreased communication costs that have allowed management of supply chains from a remote location (more on this in Duranton and Puga (2005)) etc.We focus only on the latter for the sake of simplicity, as there are strong reasons to believe some of the other forces of globalization have also acted in the same direction.

ductions in this measure of "communication"costs will represent our definition of deepening international economic integration, and studying the economic geography impacts of economic integration defined in this way will be the main emphasis of the paper.

3.3 Model Set-Up: Consumption

The consumption side of the economy will be specified in the simplest possible way, with the preferences of the representative worker/ consumer, irrespective of skill level or location being specified by the utility function:

$$U(c) = c \tag{6}$$

where c represents the consumption of the final (assembled) good.

Thus, in our model, agents can derive utility either by undertaking the non-market, subsistence activity in the hinterland, or through consumption according to the utility function above. Agents can thus choose their location, occupation and consumption such as to maximize utility. As agents are assumed to be ex-ante identical, and to face no mobility costs across locations within countries or sectors, any equilibrium will involve indifference across locations and occupations within countries.

Perhaps the most surprising and non-standard (in the context of an economic geography model) aspect of the proposed specification is that land (housing) consumption plays no role in agents' utility. This assumption is maintained for the sake of simplicity; extending the model by incoporating housing consumption in agents' preferences would not substantively affect the results.[16]

3.4 Model Set-Up: Equilibrium

With the set-up characterized above, we will proceed to define an equilibrium of the world economy as follows:

Definition 1. *A (world) equilibrium will represent an allocation of workers across locations and sectors* $\left\langle H^i_{S1}, L^i_{S1}, H^i_{S2}, L^i_{S2}, H^i_{N1}, L^i_{S1}, H^i_{N2}, L^i_{N2} \right\rangle$ *with* $i \in \{1, 2, M\}$*, a collection of factor prices* $\left\langle w^S_S, w^U_S, w^S_N, w^U_N, r_{S1}, r_{S2}, r_{N1}, r_{N2} \right\rangle$ *and a collection of task/ service prices* $\langle p_1, p_2, p_M \rangle$ *such that:*

- *consumers are maximizing utility by their choice of location, occupation and consumption;*

[16] As the reader might already foresee from the very parsimonious specification of the preference side of the economy, all the interesting mechanics of the model will take place on the productive side of the economy, with workers simply "following"the location decisions of profit-maximizing firms. This equates to taking a firm stand on a relatively controversial issue in urban economics: do firms follow workers or do workers follow firms? In a recent job market paper, Rebecca Diamond (2013) estimates a structural model of local labor demand, housing supply, labor supply and amenity levels in US cities and finds some evidence to support the latter direction of causality.

- *firms in all sector (task 1, task 2 and management services) 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; and*
- *markets for all goods and intermediates, including management services clear at the level of the world economy.*

3.5 Discussion and Parameter Restrictions

Before moving to solving for the equilibria of the proposed model, a few futher clarifications and restrictions to the parameter space are in order. Firstly, in the analysis that follows we will use the framework set out above to analyze the impact of greater international economic integration (represented in our framework by declining communication costs for management services - τ) on the location of economic activity, and its implications for economic geography.

In effect, a reduction in communication costs will capture our notion of deepening economic integration. As previously stated, this is merely a convenient simplification and alternative ways of modelling deepening economic integration, such as for instance reduced transportation costs for goods and services, or reduced trade barriers would yield similar implications. Moreover, as the analysis of the proposed framework will hopefully make clear, other forces beyond economic integration could yield similar effects to the ones discussed herein. Thus, in a fully integrated world economy (subject only to international immobility of factors), any shock to factor endowments or technology of a country can be expected to have similar types of economic geography consequences as the ones discussed below. As a result, even if we are analyzing a very stylized, analytically tractable setting, the qualitative conclusions we will draw will also apply in more general settings.

Secondly, for the model to deliver interesting results, we will have to impose a few additional parameter restrictions, namely:[17]

- The unskilled sector (producing task 1) of the economy is small enough relative to the skilled (task 2 producing) sector:

$$\frac{1-a}{a} > \frac{2\frac{K_1}{1+K_1}}{[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}\left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{7}$$

  where K_1 denotes a constant with $K_1 = A^{\frac{\beta}{1-\beta}}$ and $A > 1$ is the common exogenous endowments of the productive amenity characterising cities (locations) $S2, N1$ and $N2$.

[17] More details on these parameter restrictions, including their derivation, are available in the appendix

- The difference between the outside options available in the hinterland of the two countries (which will be reflected in the wage differentials between the two countries) is large enough:

$$\frac{u_N}{u_S} > \left\{ \frac{(1-\gamma) - \gamma(1-\alpha)(1-\gamma')}{\gamma(1-\alpha)(1-\gamma')} \right\}^{\frac{1-\beta}{\beta}} \tag{8}$$

Further, we will also make a more restrictive parameter restriction on the relative size of the two main sectors in our model economy. This assumption is not critical (similar results would prevail in its absence) but helps us pinpoint the path of the reallocations of economic activity as economic integration (lowering of τ) progresses. In particular, this parameter restriction will indicate in which country the relatively more skilled city will first completely specialize in that country's relatively more skilled industry (i.e. will the North's advanced city specialize in management services before/ after the South's advanced city specializes completely in task 2? - we will assume the latter is the case):

$$\frac{1-a}{a} > \frac{2(1+K_1)}{[(1-\gamma) + \gamma(1-\alpha)(1-\gamma')]} \times \left[\frac{\gamma(1-\alpha)(1-\gamma')}{(1-\gamma) - \gamma(1-\alpha)(1-\gamma') + \frac{a}{1-a}} + \frac{K_1}{2(1+K_1)} \right] \tag{9}$$

Intuitively, the parameter restrictions above are meant to ensure that the constraint imposed on the production possibilities of the South by the presence of communication costs for management services is (sufficiently) binding.

Finally we should note that the analysis undertaken in the next section will focus on stable equilibria in which the management services sector, which by assumption is subject to localization economies, has successfully clustered in one of the two locations in the North (we have assumed that the North has some overwhelming advantage in producing these services).[18]

Without loss of generality we will work under the assumption that the management services sector agglomerates in city $N2$. We will further also assume that the posited localization economies affecting the management services sector are strong and and convex enough such that, along our entire analysis, equilibria in which the entire management services sector is clustered in one location exist and are stable.

3.6 Solving the Model

Having made sufficient assumptions to allow for tractable analysis of the model, in this section we will outline the process of solving the model (which is further

[18] It is easy to see that there will always be equilibria with symmetric Northern cities, in which the management services sector is split equally between the two cities of the North. In many cases these equilibria will not be stable and they will also not be (Pareto) efficient. However we will not considere these equilibria, and will focus our analysis on the more interesting equilibria with asymmetric Northern cities

developed in the appendix) and derive the main theoretical results.

Starting from the labor markets, our assumptions regarding the perfect (within-country) geographical and occupational mobility of workers, as well as the access of workers to an identical education technology guarantee that in any equilibrium wages are pinned down in both countries by supply side conditions:

$$w_S^U = u_S \qquad w_S^S = \frac{u_S}{1-\epsilon} \tag{10}$$

$$w_N^U = u_N \qquad w_N^S = \frac{u_N}{1-\epsilon} \tag{11}$$

From the demand side of the labor markets, we can derive the wage bills for each type of worker at each location:

$$w_l^U L_l(1) = \beta Y_l(1) \qquad \text{where } Y_l(1) = p_1 * q_l(1) \tag{12}$$

$$w_l^U L_l(2) = \beta(1-\gamma) Y_l(2) \qquad \text{where } Y_l(2) = p_1 * q_l(2) \tag{13}$$

$$w_l^S H_l(2) = \alpha\gamma Y_l(2) \tag{14}$$

with $l \in \{S1, S2, N1, N2\}$. The assumption of constant returns to scale production functions also guarantees that:

$$\sum_{l \in \{S1,S2,N1,N2\}} \sum_{i \in 1,2} Y_l(i) = Y \tag{15}$$

where Y denotes world GDP.

From the assumptions of perfectly competitive markets for the intermediate tasks and costless transport of these tasks (intermediates) across and within countries, we have that each task will only be produced at worldwide cost minizing locations:

$$p_1 = \min_{l \in \{S1,S2,N1,N2\}} c_l(1) \tag{16}$$

$$p_2 = \min_{l \in \{S1,S2,N1,N2\}} c_l(2) \tag{17}$$

where $c_l(i)$ represents the minimum cost of production of intermediate task i at location l. In turn the cost functions are given by the expressions:

$$c_l(1) = \left(\frac{1}{A_l}\frac{w_l^U}{\beta}\right)^{\beta} \left(\frac{r_l}{1-\beta}\right)^{1-\beta} \tag{18}$$

$$c_l(2) = \left[\frac{1}{\gamma}\left(\frac{1}{A_l^{\rho}}\frac{w_l^S}{\alpha}\right)^{\alpha}\left(\frac{p_l^M}{1-\alpha}\right)^{1-\alpha}\right]^{\gamma} \left[\frac{1}{1-\gamma}\left(\frac{1}{A_l}\frac{w_l^U}{\beta}\right)^{\beta}\left(\frac{r_l}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma} \tag{19}$$

where beyond the previously established notation, p_l^M represents the price of management services at location l and A_l represents the endowment of the productive amenity at location l.

Regarding the management services sector of the economy, we have made sufficient assumptions to guarantee that equilibria will exist in which the entire sector will be clustered in one of the Northern locations.[19]. Moreover from the demand structure of the model we can derive simple expressions for the revenues of the management services sector and the remuneration of the primary factors employed in their production:

$$p_M^N M = Y_M = \gamma(1-\alpha)(1-a)Y \tag{20}$$

$$w_N^S H_{N2}(M) = \gamma' Y_M \tag{21}$$

$$w_N^U L_{N2}(M) = \beta(1-\gamma')Y_M \tag{22}$$

Given that we will restrict attention to equilibria in which the management services sector is clustered in city $N2$ we can also derive expressions for the prices of management services at various locations:

$$p_M^N = \frac{1}{B_{Max}} \left(\frac{1}{A_l^\rho}\frac{w_N^S}{\gamma'}\right)^{\gamma'} \left[\frac{1}{1-\gamma'}\left(\frac{1}{A_l}\frac{w_N^U}{\beta}\right)^{\beta}\left(\frac{r_{N2}}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma'} \tag{23}$$

$$p_M^S = \tau p_M^N \tag{24}$$

Where, the p_N^M denotes the (unique) price of management sevices in the North, p_S^M denotes the price of management serives in the South and the productivity term is given by:[20]

$$B_{Max} = \xi_N F(1) \tag{25}$$

where the notation emphazises that the management services are produced with the maximal possible productivity when the sector is clustered in only one of the Northern locations.

Given that a number of key factor prices (e.g. skilled and unskilled wages in both the North and South) are exogenously fixed in our model by the presence of the outside option offered by the countries' hinterlands, land rents will represent the main margin of adjustment to equilibrium. Thus, land prices will adjust such that the demand for land equates the inelastic land supply at each location:

$$r_l \bar{N} = \beta Y_l(1) + \beta(1-\gamma)Y_l(2) + \beta(1-\gamma')Y_l(M) \ \forall l \ \in \{S1, S2, N1, N2\} \tag{26}$$

Finally, by the assumption that the final good is costlessly assembled from intermediates 1 and 2 under conditions of perfect competition, and by its designation as the numeraire we obtain the condition:

$$P = \left(\frac{p_1}{a}\right)^a \left(\frac{p_2}{1-a}\right)^{1-a} = 1 \tag{27}$$

[19]Without loss of generality we will assume that the management services sector always clusters in city $N2$ to keep the consistency of notation i.e. cities indexed with two will be the advanced city in each country

[20]Note that we have assumed that transport of management services is costless within countries, and the cost of importing management services into a country is symmetric across its locations

With the above results in place, we next characterize the equilibria of interest for varying values of the degree of international economic integration which we model via our measure of "communication"costs for management services. When performing this comparative static exercise we will be particularly interested in following how a reduction in international communication costs will affect cities' populations, skill share and real estate prices, as well as overall (worldwide) urbanization. While real estate prices in equilibrium will be pinned down by equation (26) above, the expressions for a city's equilibrium populations and skill shares will be given by:

$$Pop_l = \sum_{i\in\{1,2,M\}} L_l(i) + \frac{1}{1-\epsilon}\sum_{i\in\{1,2,M\}} H_l(i) \tag{28}$$

$$\frac{H_l}{L_l} = \frac{\frac{1}{1-\epsilon}\sum_{i\in\{1,2,M\}} H_l(i)}{\sum_{i\in\{1,2,M\}} L_l(i)} \tag{29}$$

3.7 Main Results

We are now ready to proceed to presenting our main results, which will involve characterising the evolution of the equilibria of interest[21] as economic integration deepens. We begin by considering the case of prohibitively high international communication costs for the transmission of management services, and then proceed to analyzing equilibria that can be expected to prevail under progressively lower communication costs (i.e. with deeper international economic integration). Proposition 1 summarizes our results under very large communication costs:

Proposition 1. *When communication costs are high enough namely*

$$\tau > \underbrace{\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}} \left\{\frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{2\frac{K_1}{1+K_1}a}\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}}}_{T_{max}} \tag{30}$$

then the only stable equilibrium involves activity 1 *locating in* S*, activity* 2 *locating in both* $N1$ *and* $N2$*, and the management services sector locating in* $N2$*.*

Moreover in this equilibrium we have that $Pop_{S2} > Pop_{S1}$*,* $Y_{S2} > Y_{S1}$*,* $r_{S2} = K_1 r_{S1}$ *where* $K_1 = A^{\frac{\beta}{1-\beta}} > 1$*,* $Pop_{N2} > Pop_{N1}$*,* $Y_{N2} > Y_{N1}$*,* $r_{N1} = r_{N2}$*,* $\frac{H_{S1}}{L_{S1}} = \frac{H_{S2}}{L_{S2}}, \frac{H_{N1}}{L_{N1}} < \frac{H_{N2}}{L_{N2}}$

Proof: See Appendix.

The above result merely depicts a snapshot of the location of economic activity

[21] Again, by equilibria of interest we mean equilibria in which management services providers have successfully clustered in only one of the Northern locations, which for convenience we will label $N2$. Also note that under our assumptions all equilibria will feature the management services sector exclusively located in the Northern locations, which are assumed to be overwhelmingly more productive in this sector

in a pre-globalization world. In the presence of prohibitively high communication costs for management services, coupled with very low Southern productivity in producing management services, the South is going to be unable to produce the advanced task, as it requires management services as an essential input. In this context the world equilibrium will feature a (relatively) poor South that is completely specialized in the production of task 1 and a much richer North which undertakes the production of both task 2 and management services. In this context, the Southern cities start out as relatively undifferentiated in terms of both size and industrial structure, and have identical skill shares given by the production technology of the dominant low-skilled industry. The more advanced city $S2$ will display higher population and higher land prices, due to its greater endowment in the exogenous productive amenity A. Moreover, due to the small size of the "formal"economy, the South will also be predominantly "rural"with a large fraction of workers remaining in the hinterland.

In the North, the only stable equilibrium, up to a permutation of city labels, involves the entire management services sector clustering into one of the two available locations. Thus, the Northern cities are differentiated in terms of both industrial structures and skill shares, with the more skilled city $N2$ housing the entire management services sector and some task 2 production, while the less skilled city $S1$ is completely specialized in task 2 production. Moreover, due to the greater density of employment in the production of management services, the skilled city $N2$ displays greater population than its less skilled counterpart $N1$. However, given that the Northern cities are identical in terms of both their exogenous productive amenities and their access to management services (as we have assumed that within country communication costs are negligible) they will have the same land prices. Finally, due to its larger formal economy and assuming that it is not of larger size ($L_N \leq L_S$), the North can be expected to display greater rates of urbanization than the South.

The snapshot of a pre-globalization world offered above can be thought to imperfectly characterize the world around the middle of the twentieth century, with large disparities in income across countries, relatively small income disparities across cities (regions) within countries, subdued levels of North-South trade, capital flows and transfers of technology as well as a modest role for multinational corporations. Moreover, this initial snapshot features low levels of geographical segregation of the skilled in both North and South and relatively modest within country disparities in the price of non-tradables, most notably land.

However, as the twin forces of globalization and technology become more important, the above equilibrium configuration can be expected to change. Thus, as communication costs fall, eventually below the threshold T_{Max} presented in Proposition 1, the South becomes increasingly competitive in producing the more advanced task 2. As a result, the South gradually captures more and more of the production activity in task 2, and hence begins a process of catching up to the richer North (i.e. the South's share of world GDP increases). Moreover, as the size of the South's "formal"economy grows, so will both of its cities, and thus more and more population will be drawn from the hinterland to the cities,

leading to an increase in the South's urbanization rate, which will become more similar to that of the North.

This catch-up process of the South relative to the North does not proceed evenly though, as the South's advanced location $S2$ becomes competitive in the production of task 2 "before" the more backward location $S1$. Thus, in the early stages of economic integration, the advanced Southern location will attract more and more of the task 2 producing activity and as a consequence will grow its population faster than the more backward city $S1$. Moreover, as it captures task 2 production, location $S2$ at first opens and then widens a skill-share differential relative to the more backward city $S1$.

The implications of this gradual relocation of task 2 production from North to South are also not symmetric for locations in the North. As the South becomes increasingly competitive in task 2 production, both Northern locations gradually shed task 2 production activities and its affiliated jobs. However, whereas city $N1$ is (in our equilibrium of interest) completely specialized in task 2 production, and is thus vulnerable to Southern competition in the production of task 2, city $N2$ benefits from a compensating force.

To see this, note that as the communication frictions between North and South are reduced, we will not only observe a reallocation of economic activity from North to South but also an increase in the size of the (formal) world economy, which can now operate with greater efficiency. Thus, while the North-South reallocation of activity negatively impacts both Northern cities, the management services cluster in city $N2$ stands to benefit from the lessening of communication frictions, as it can now sell its product to a larger and more efficient world economy. This growth of the management services sector will serve to cushion the negative impact of task 2 relocation for city $N2$ in the early stages of globalization and can eventually allow city $N2$ to grow even as its task 2 sector shrinks in the face of Southern competition.

As a result of the mechanism described above, the Northern cities will thus also display some divergence in outcomes in the early stages of globalization (i.e. τ falling below T_{Max}): city $N2$ will augment its skill advantage over $N1$ as the management services sector becomes a bigger part of its economy and, morever, $N2$ will shed population at a slower pace than $N1$ because of the compensating force provided by a growing management services sector. Land prices will, however, remain equalized across Northern cities in the early stages of globalization for the same reasons as before: the Northern cities are symmetric both in terms of their productive amenities and in terms of their access to advanced (management) imputs, and thus provide an equally attractive productive environment for the activity that is on the margin between locating in city $N1$ and city $N2$, namely activity 2.

The results presented above concerning the early stage of globalization are summarized in Proposition 2 below.

Proposition 2. *There exists an interval of communication costs, namely:*

$$\underbrace{\left\{\frac{(1-a)\left[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')\right]-aK_1}{2K_1a}\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}}\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}}}_{T_{spec1}}<\tau\leq T_{max} \tag{31}$$

in which the unique stable equilibrium (subject to a permutation of Northern cities) features task 2 being produced in locations $\{S2, N1, N2\}$*, task* 1 *being produced in both Southern cities while the management services (M) are produced in* $N2$*.*
Moreover, along this interval, a reduction in communication costs ($\tau\downarrow$) *results in:*

$Pop_{S1}\uparrow$,$Pop_{S2}\uparrow$, *with* Pop_{S2} *growing faster than* Pop_{S1}, $Pop_{N1}\downarrow$, *ambigous impact on* Pop_{N2} *but a decline in the upper part of the interval,* $r_{S1}\uparrow$, $r_{S2}\uparrow$ $r_{N1}=r_{N2}\downarrow$,$Y\uparrow$, $Y_{S1}\uparrow$,$Y_{S2}\uparrow$, $Y_{N1}\downarrow$, Y_{N2} *ambigous overall, but declining in the upper part of the interval,* $\frac{H_{S1}}{L_{S1}}$ =*constant* ,$\frac{H_{S2}}{L_{S2}}\uparrow$,$\frac{H_{N1}}{L_{N1}}$ =*constant,* $\frac{H_{N2}}{L_{N2}}\uparrow$, *world urbanization* $\uparrow$

Proof: See Appendix.

As globalization proceeds further, eventually the advanced cities $S2$ and $N2$ will become completely speiclized in their country's most advanced activity, namely task 2 in the South and management services (M) in the North. Given our parameter restrictions in section 3.5 we will have that the advanced Southern city will become completely specialized in task 2 before its Northern counterpart becomes specialized in management services.[22] Thus, as the falling costs of international communication touch the threshold T_{spec1} in Proposition 2 above, the advanced Southern city $s2$ becomes completely specialized in the production of task 2.

Below T_{spec1} there will be an interval of communication costs for which adjustments to further reductions in communication frictions will be similar to the ones outlined in Proposition 2 for Northern locations, but qualitatively different for the Southern locations. In particular, as city $S2$ becomes fully specialized in task 2, the margin of further adjustment to continuing communication improvements will no longer be city $S2$'s industrial structure, but its land prices. As a result, for at least an interval of communication costs below T_{spec1}, there will be divergences in real estate prices across Southern locations, with the more advanced location witnessing more rapid land price appreciation than the backward location $S1$. During this interval, however, the skill divergence across Southern locations will stop, while the divergence in population growth rates will continue, with the more skilled city continuing its more rapid population and employment growth. Beyond this interval of communication costs, below T_{spec1} it becomes theoretically possible that city $S1$ also becomes competitive in

[22] As previously mentioned this parameter restriction and its "timing"implications concerning the specialization of the advanced cities do not have important implications for uour results, but merely allow for a more synthetic exposition of equivalent sub-cases

the production of task 2. However, to avoid the proliferation of subcases, in the main formal discussion in this paper we will maintain the assumption that the South's backward city's relative lack of the productive amenity remains binding along our entire analysis, and thus $S1$ never produces task 2. An informal discussion of alternative scenarios in which the South's backward city is less limited in its productive capacities is provided in the Appendix.

We will summarize the discussion in the previous paragraph in the following proposition:

Proposition 3. *Under the parameter restrictions of section* 3.5 *and for large* ρ *there exists an interval of communication costs, namely:*

$$\underbrace{\left\{\frac{\gamma(1-\alpha)(1-\gamma')}{(1-\gamma)-\gamma(1-\alpha)(1-\gamma')}\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}}\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}}}_{T_{spec2}} < \tau \leq T_{spec1} \quad (32)$$

in which the unique stable equilibrium (subject to a permutation of Northern cities) features task 2 being produced in locations $\{S2, N1, N2\}$*, task* 1 *being produced in* $S1$ *while the management services (M) are produced in* $N2$*.*
Moreover, along this interval, a reduction in communication costs ($\tau \downarrow$) *results in:*

$Pop_{S1} \uparrow$,$Pop_{S2} \uparrow$, *with* Pop_{S2} *growing faster than* Pop_{S1}, $Pop_{N1} \downarrow$, *ambigous impact on* Pop_{N2}, $r_{S1} \uparrow$, $r_{S2} \uparrow$, $\frac{r_S 2}{r_S 1} \uparrow$ $r_{N1} = r_{N2} \downarrow$,$Y \uparrow$, $Y_{S1} \uparrow$,$Y_{S2} \uparrow$, $Y_{N1} \downarrow$, Y_{N2} *ambigous overall,*$\frac{H_{S1}}{L_{S1}}$ $=$*constant* ,$\frac{H_{S2}}{L_{S2}}$ $=$*constant,*$\frac{H_{N1}}{L_{N1}}$ $=$*constant,* $\frac{H_{N2}}{L_{N2}} \uparrow$, *world urbanization* $\uparrow$

Should globalization proceed further, and communication costs fall below the threshold T_{spec2}, then the skilled city of the North will specialize in the production of management services. As before, beyond T_{spec2} there will be an interval of communication costs where adjustments to further communication improvements will generate similar outcomes to the ones detailed in Proposition 3 for Southern locations. However, now outcomes for Northern locations will be qualitatively different, as differential land prices will become the new margin of adjustment along the equilibrium path of interest, with industrial structures remaining stable to further changes in communication frictions. Along this interval, land prices will begin diverging between $N2$ and $N1$ (with $N2$ displaying real estate price appreciation, while $N1$ land price continues its decline), the population and employment divergence between $N2$ and $N1$ will widen as $N2$ enters a path of unambigous population and employment growth while $N1$ continues to decline on both measures. However, on this interval skill divergence across Northern locations will cease as the industrial structures of Northen cities stop changing. These results are summarized in the following proposition:

Proposition 4. *Under the parameter restrictions of section* 3.5 *and for large* ρ *there exists an interval of communication costs, namely:*

$$\underline{\tau} < \tau \leq T_{spec2} \quad (33)$$

in which there exists a stable equilibrium (subject to a permutation of Northern cities) features task 2 being produced in locations $\{S2, N1\}$*, task* 1 *being produced in* $S1$ *while the management services (M) are produced in* $N2$*.*
Moreover, along this interval (restricting attention to equilibria of interest), a reduction in communication costs ($\tau \downarrow$) *results in:*

$Pop_{S1} \uparrow$,$Pop_{S2} \uparrow$, *with* Pop_{S2} *growing faster than* Pop_{S1}, $Pop_{N1} \downarrow$, $Pop_{N2} \uparrow$, $r_{S1} \uparrow$, $r_{S2} \uparrow$, $\frac{r_S 2}{r_S 1} \uparrow$ $r_{N1} \downarrow$,$r_{N2} \uparrow$,$Y \uparrow$, $Y_{S1} \uparrow$,$Y_{S2} \uparrow$, $Y_{N1} \downarrow$, $Y_{N2} \uparrow$,$\frac{H_{S1}}{L_{S1}}$ =*constant* ,$\frac{H_{S2}}{L_{S2}}$ =*constant*,$\frac{H_{N1}}{L_{N1}}$ =*constant,* $\frac{H_{N2}}{L_{N2}}$ =*constant, world urbanization* $\uparrow$

The narrative jointly provided by the results reported in propositions 1-4 above is qualitatively consistent with observed urban outcomes outcomes over the past few decades. Contemporaneous with deeper economic integration we have witnessed the steady rise of developing world cities. However this rise has not been homogenous, with some regions and cities in the South, particularly the more skilled and technologically advanced ones, and the ones with the best market access, displaying the more robust urban growth. Perhaps more importantly, the results qualitatively match the more complex developments observed in the case of Northern cities. Thus, in the case of the United States for instance, the period 1950-1980 featured urban decline almost across the board, with major cities, both skilled and unskilled, shedding population and employment and registering drops in real estate prices. In the subsequent period however (1980-2000), there has been marked divergence in urban outcomes across different types of cities, as skilled metropolitan areas have tended to recover and enter a path of population, employment and real estate price growth, while many unskilled cities have continued their decline.[23]

The final set of results reported in this section will offer an insight into an interesting scenario that could unfold should international communication frictions continue to decline. As the reader may have noted, proposition 4 above leaves unspecified the lower bound of the relevant interval of communication costs, simply denoting it as $\underline{\tau}$. This is because the framework as it is set out above, including our parameter restrictions (those detailed in section 3.5 and the assumption of a very high parameter ρ) still nests two subcases about the developments of economic geography that could prevail (along the path of equilibria of interest) for very low international communication frictions. Thus, if the size of the task 1 producing sector is small and the differential in the outside options offer by the countries' hinterlands is not too large, such that:

$$\frac{a}{1-a}\frac{K_1}{1-\gamma}\left[\left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}}+\left(\frac{u_N}{u_S}\right)^{\frac{\alpha}{1-\beta}\frac{\gamma}{1-\gamma}}\right]<1 \tag{34}$$

then we will have that $\underline{\tau}=1$ and Proposition 4 concludes our characterization of the comparative static implications of gradual communication costs reductions. If on the other hand the inequality in relation (34) above is reversed, then we

[23]The above facts about city growth patterns over the 1950-2000 period in the United States, are documented, among others by Glaeser and Ponzetto (2010)

will have that

$$\underline{\tau} = \left\{ \frac{a}{1-a} \frac{K_1}{1-\gamma} \left[\left(\frac{u_S}{u_N} \right)^{\frac{\beta}{1-\beta}} + \left(\frac{u_N}{u_S} \right)^{\frac{\alpha}{1-\beta} \frac{\gamma}{1-\gamma}} \right] \right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} > 1 \tag{35}$$

and then we still have one range of feasible communication costs for which we need to characterize the equilibria of interest and the relevant comparative statics. This is done in proposition 5 below:

Proposition 5. *Under the parameter restrictions of section* 3.5 *and for large* ρ *there exists an interval of communication costs, namely:*

$$1 < \tau \leq \underbrace{\left\{ \frac{a}{1-a} \frac{K_1}{1-\gamma} \left[\left(\frac{u_S}{u_N} \right)^{\frac{\beta}{1-\beta}} + \left(\frac{u_N}{u_S} \right)^{\frac{\alpha}{1-\beta} \frac{\gamma}{1-\gamma}} \right] \right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}}}_{\underline{\tau}} \tag{36}$$

in which there exists a stable equilibrium (subject to a permutation of Northern cities) features task 2 being produced in locations $\{S2, N1\}$*, task* 1 *being produced in* $\{S1, N1\}$ *while the management services (M) are produced in* $N2$*. Moreover, along this interval (restricting attention to equilibria of interest), a reduction in communication costs (*$\tau \downarrow$*) results in:*

$Pop_{S1} \downarrow$,$Pop_{S2} \uparrow$, $Pop_{N1} \downarrow$, $Pop_{N2} \uparrow$, $r_{S1} \downarrow$, $r_{S2} \uparrow$, $r_{N1} \downarrow$,$r_{N2} \uparrow$,$Y \uparrow$, $Y_{S1} \downarrow$,$Y_{S2} \uparrow$, $Y_{N1} \downarrow$, $Y_{N2} \uparrow$,$\frac{H_{S1}}{L_{S1}}$ =*constant* ,$\frac{H_{S2}}{L_{S2}}$ =*constant*,$\frac{H_{N1}}{L_{N1}} \downarrow$, $\frac{H_{N2}}{L_{N2}}$ =*constant, world urbanization* $\uparrow$

In this final range of communication costs, interesting new developments in economic geography occur. Firstly, it becomes clear that the skilled city of the South "overtakes"the unskilled city of the North along the global supply chain. By this we mean that the skilled city of the South displays a more skill intensive industrial structure than the unskilled city of the North.[24] Moreover, along this interval, the unskilled Northern city has lost so much of the task 2 producing activity such that its very depressed land prices make it competitive in the production of task 1. As a result, city $N1$ become a competitor of the South's unskilled city $S1$, capturing more of task 1 production as it surrenders more of the task 2 production activity to the increasingly competitive location $S2$.[25] As

[24] In an important sense "overtaking"of the North's unskilled city by the South's skilled city already occurs when communication costs fall below $\left(\frac{u_N}{u_S}\right)^{\frac{\alpha}{1-\alpha}}$. At that point, the bundle of advanced inputs (skilled labor and management services) becomes cheaper in $S2$ relative to $N1$, and as a consequence, $N1$ can only retain task 2 production by having a lower costs of the backward inputs (land and unskilled labor)

[25] Along this interval the model predicts that the continued shift of task 2 production from N to S could be accompanied by a shift in the opposite direction of the task 1 producing activity. This could be given the interpretation, from the North's perspective, of contemporaneous offshoring and re-shoring, with the intermediate skill sector 2 increasingly moving to the South, while the low-skilled activity returns to the North, after a period in which is it was undertaken only in the South.

a result both unskilled cities $S1$,$N1$ exhibit declines across the main measures of urban success (population and land prices) while the skilled cities of both countries continue their ascendancy. Another intersting development that emerges along this range of communication costs is the possibility of deskilling. Thus, as location $N1$ continues shedding task 2 employment and becomes increasingly attractive for task 1 producers, its industrial structure and population composition becomes increasingly unskilled, and skill divergence across Northern locations re-emerges.

4 Empirical Support

In the preceding sections we have set-up a stylized model of the world economy and have drawn out some of its potential implications. In particular, in the preceding sections we have shown how, under some restrictions, the model produces a history of economic geography that is broadly consistent with some of the salient trends in economic geography observed in the data. However, the simple consistency of the model's predictions with observation does not serve to validate the model. Furthermore, the model's stylized nature precludes it from being formally taken to the data. As a result, in this section we will review some empirical findings from the literature that would seem to support the mechanisms highlighted in our theory. The evidence discussed in this section should be regarded as providing suggestive support for the proposed conceptual framework described in the preceding sections.

In an important sense, the theory provided in the preceding section can be described as a theory of local labor markets and of the impact of international economic integration on local labor markets. The mechanics of the model revolve around the asymmetric effects of deepening globalization across labour markets within countries and on the implications of these shocks to local labor markets for within country economic geography and in particular for the patterns of location of various types of agents. Thus, for the proposed theory to shed light on mechanisms that are empirically important, it has to be the case that factors pertaining to international economics (i.e. international trade, FDI, technological transfer) have a quantitatively important influence on local labor markets in both the North and South.[26] Evidence that this is in fact the case is provided, among others, in Autor, Dorn and Hanson (2013), who show that local labor markets (which they define as commuting zones), that, due to the sectoral composition of their economies, are exposed to more intensive import

[26]The importance of trade and outsourcing for national labor markets has been a subject to intense debate in the international economics literature for more than two decades. Thus, among others, Berman, Bound and Griliches (1994), Lawrence (1994) and Krugman (1994) argue that outsourcing is to small to account for the observed wage and employment changes in the US. On the other hand while Feenstra and Hanson (1997), taking a more expansive definition of outsourcing argue that it is responsible for a substantial fraction of the growth of skill premia in the United States. More recently, as both outsourcing and trade flows have greatly increased in magnitude the consensus has shifted decisively towards the view that trade and outsourcing can have substantial effects on labor markets.

competition from China tend to display weaker labor market performance than local labor markets that are more shielded from Chinese import competition. This weaker labor market performance is manifested across measures such as employment, labor force participation, unemployment, average wages and social security benefits.[27] Similarly, Topalova (2005, 2010) finds evidence that trade liberalization has differential impacts on inequality and poverty levels across rural districts in India while Kovak (2013) finds a significant impact of trade-liberalization induced price declines on wages across Brazilian regions.

Having convinced ourselves that forces pertaining to international economics can have substantial differential effects on local labor markets, the next question we need to consider when attempting to establish the validity of the proposed theory is whether it is indeed the case that international economic integration has been accompanied by a trend of developing countries capturing (i.e. gaining a significant market share) increasingly complex activities along global supply chains. Some evidence that this is in fact the case is offered, for the case of China, by a number of papers including Schott (2006), Rodrik (2006), Hausmann, Hwang and Rodrik (2007) and Jarreau and Poncet (2012). This strand of papers generally relies on building measures of export sophistication of countries and analyzing the implications of these measures and their changes on various economic outcomes[28]. For the purposes of the present paper, the study of Jarreau and Poncet (2012) is particularly interesting, as they document not only that China's export sophistication is growing over time (which would lead us to believe that the sophistication of its productive sector is also increasing), but also that there are significant regional disparities in export sophistication within China (at the province and prefecture level) and that regions displaying greater export sophistication tend to display more rapid economic growth. All of these findings are consistent with the theory provided.

Furthermore, the mechanism highlighted by our theory, which involves a shift of productive activities along the global supply chain, can be given two alternative interpretations. The relocation of production in marginal sectors from North to South could occur by entry of domestic Southern firms into new sectors as productive conditions in these industries improve due to decreasing transportation and communication costs. Alternatively, we could observe that Northern firms specializing in producing middle skill intermediates/task (which have expertize in producing these tasks) shift production to the South, thus engaging in offshoring activities.

While both phenomena are likely to be at work in reality, documenting the latter interpretation of the proposed mechanism is perhaps easier, as offshoring

[27] On the other hand, Autor, Dorn and Hanson (2013) do not find a significant effect of import exposure on the population of commuting zones. This is surprising, given the relatively long time span covered by their dataset and would seem to indicate significant impediments to geographic and/or sectoral mobility.

[28] One of the interesting findings in this literature, which has spawned a large number of papers, is that China has a surprisingly high level of export sophistication relative too its overall level of economic development. In particular Schott (2006) discusses the large and expanding overlap between China's exports and the export set of developed countries, a finding which is consistent with the mechanism highlighted by our theory.

is often accompanied by an observable trail of foreign direct investment (FDI). The findings of the FDI literature seem to be largely consistent with the mechanics proposed by the model: FDI flows to a greater extent to the more skilled regions of developing countries (Nunnenkamp 2002), affiliates of foreign entities tend to be more skill intensive than domestic firms (Feenstra and Hanson 1997), and FDI flows seem to be 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, as Wei (1999) documents for the case of Chinese cities. Overall the evidence is consistent with the idea of FDI representing a skill biased force of cumulative causation, with more skilled locations attracting more FDI, which in turn causes this location both to grow faster and to increase their skill intensity. This idea is captured, albeit imperfectly in our theory.[29]

There is also some evidence consistent with the former interpretation of our theory, namely that economic integration can yield changes in Southern productive conditions that make domestic firms more competitive and able to enter new (potentially higher value added) lines of activity. Note that although in the exposition of our model we denoted the advanced intermediate input for which the North has an overwhelming productivity advantage as "management services"we can allow for a wider intrepretation of M as advanced intermediate inputs.

With this expanded interpretation of advanced intermediates in mind, we can find several studies in the trade literature that empirically document mechanisms that are consistent with our theory. Thus, Amiti and Konings (2007), analyzing a sample of Indonesian manufacturing firms find that cheaper foreign intermediates that become available due to trade liberalization have a substantial impact on the productivity of domestic firms.[30] Moreover, Eaton and Kortum (2001) document that innovative activity and production of capital goods is concentrated in a few developed countries, that a substantial part of cross country differences in productivity stem from variation in the relative price of equipment and that, in turn, trade barriers account for half of the cross country price differentials for equipment. Moving even closer to our theory's narrative, Goldberg, Khandelwal, Pavnick and Topalova (2009, 2010) analyzing a sample of Indian firms find that the availability of foreign intermediates not only increases domestic firms productivity but allows them to also increase the scope of their production while Feng, Li and Swenson (2013) document the same patterns for China.

Finally, after reviewing the empirical support for the presence of a signif-

[29]The idea of FDI as a force of cumulative causation would be more accurately captured in a model which also included mobile capital as well as endogenous productive amenities deriving from the local presence of skilled workers. However these additions would add substantially to the complexity of the model.

[30]The finding of Amiti and Konings, coupled with other findings from the literature (such as those of Bernard and Jensen 2004) yield another interesting and relevant implication: breaking down trade barriers is likely to lead to the emrgence of production chains, as developing world firms that become more productive due to access to cheaper more productive may themselves be more likely to select into exporting

icant shift of productive activities from North to South, we need to further document that this shift is indeed skill-biased relative to both the North and the South (some evidence that the productive shift has been skill-biased in the South has already been provided above). Such evidence is relatively abundant in the literature. Thus, Csillag and Koren (2011) document that capital goods imports in Hungary have contributed to a rise in skill premia across Hungarian manufacurers, while similar findings are reported for Peru by Mazumdar and Quispe-Agnoli (2002). Regarding the North, Ottaviano, Peri and Wright (2013) find that offshoring displaces unskilled workers and at the same time raises the average complexity of tasks performed by natives in the US while Lu and Ng (2012) find that industries that face greater import competition tend to employ more workers with non-routine skills and fewer with routine skills. Lastly, Jensen (2008) provides evidence that tradeable services tend to employ more educated workers and pay higher wages, and that high tech services account for a high share of services that are tradeable. Moreover, Jensen (2007) also documents that the US has a comparative advantage in tradable services, which are thus less likely to be vulnerable to offshoring, and that this category of services have displayed robust employment growth, roughly in line with services in general (tradable and nontradable).

5 Conclusion

This paper has presented a simple model that formalizes the hypothesis that international economic integration has been an important driver of the (relatively) recent observed trends in within-country economic geography. Though very stylized, the model can qualitatively match a number of interesting patterns observed in the data: rapid worldwide urbanization, the more robust growth performance of skilled cities across a range of measures of urban success (population and employment growth, real estate price growth) and skill polarization across cities. While the model's very stylized nature precludes formally taking it to the data, a discussion documenting suggestive empirical support for every step of the proposed mechanism is provided. In future work I will aim to develop formal empirical settings to help identify and measure the impact of international economic integration on the location of economic activity within countries, with a particular focus on cities.

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6 Annex

6.1 Deriving the First Parameter Restrictions

We will begin the formal treatment of the model outlined in the main body of the paper by justifying the first parameter restriction made in section 3.5, equation (5). This restriction allows for the unskilled task 1 to locate exclusively in the South and for the South to become exclusively specialized in task 1 in the case of very high communication costs. Given that very high communication costs will trivially lead to task 2 not being performed at all in the South, we need to ensure that the task 1 sector is small enough to "fit"completely in the South when it produces nothing else. The conditions for this to be the case are developed below.

In a conjectured equilibrium in which the South produces only task 1, then task 1 will be produced in both Southern cities (given that production functions are Cobb-Douglas and include land, no city can be empty in any equilibrium). Thus we have that prooduction costs for task 1 are the same in both Southern cities:

$$c_{S1}(1) = c_{S2}(1) \tag{37}$$

Developing the above equation we obtain:

$$\left[\frac{1}{A}\frac{u_S}{\beta}\right]^{\beta}\left[\frac{r_{S2}}{1-\beta}\right]^{1-\beta} = \left[\frac{u_S}{\beta}\right]^{\beta}\left[\frac{r_{S1}}{1-\beta}\right]^{1-\beta} \tag{38}$$

which after some simple manipulations yields

$$\frac{r_{S2}}{r_{S1}} = A^{\frac{\beta}{1-\beta}} = K_1 > 1 \tag{39}$$

In the conjectured equilibrium (that could prevail for very high τ) in which the entire task 1 activity and nothing else is produced in the South we have that (using properties of the Cobb-Douglas formulation of the production functions):

$$r_{S1}\overline{N} + r_{S2}\overline{N} = (1-\beta)aY \tag{40}$$

which can be rewritten, using the relations above

$$r_{S1}(1+K_1)\overline{N} = (1-\beta)aY \tag{41}$$

Thus after some manipulations we have:

$$r_{S1} = \frac{1}{1+K_1}\frac{(1-\beta)aY}{\overline{N}} \tag{42}$$

$$r_{S2} = \frac{K_1}{1+K_1}\frac{(1-\beta)aY}{\overline{N}} \tag{43}$$

In the conjectured equilibrium in which task 1 and only task 1 is located in the South, it is easy to see that task 2 will be produced in both Northern cities (if any city would contain the entire task 2 production sector it would have higher rents than the other city and no compensating advantage, and thus this would yield a force that would push task 2 production out of that city and towards the other Northern city). But, given that the two Northern cities are ex ante identical this would mean that the land rentals of the two Northern cities are equal. Thus we have:

$$r_{N1}\overline{N} + r_{N2}\overline{N} = (1-\beta)(1-a)Y\left[(1-\gamma) + \gamma(1-\alpha)(1-\gamma')\right] \tag{44}$$

$$r_{N1} = r_{N2} \tag{45}$$

Together the above relations yield

$$r_{N1} = r_{N2} = \frac{(1-\beta)(1-a)Y[(1-\gamma) + \gamma(1-\alpha)(1-\gamma')]}{2\overline{N}} \tag{46}$$

Again, for the conjectured equilibrium to exist, even for very large τ, it has to be the case that producers of task 1 do not have am incentive to deviate by relocating to the North when the whole task 1 sector is concentrated in the South while the others are produced exclusively in the North. Thus we have:

$$c_{S1}(1) = c_{S2}(1) \leq c_S(1) < c_N(1) \tag{47}$$

$$\left[\frac{1}{A}\frac{u_S}{\beta}\right]^{\beta}\left[\frac{r_{S2}}{1-\beta}\right]^{1-\beta} \leq \left[\frac{1}{A}\frac{u_N}{\beta}\right]^{\beta}\left[\frac{r_N}{1-\beta}\right]^{1-\beta} \tag{48}$$

After some manipulations the inequalities above yield:

$$\frac{r_N}{r_{S2}} \geq \left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{49}$$

Substituting (42), (43) and (46) into (49) yields

$$\frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{2\frac{K_1}{1+K_1}a} \geq \left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{50}$$

Which after a few further manipulations yields the expression of the restriction reported in the main body of the paper:

$$\frac{1-a}{a} > \frac{2\frac{K_1}{1+K_1}}{[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}\left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}}$$

6.2 Proof of Proposition 1

In this section we will outline the proof of proposition 1. Before we move to the proof of the main result, we need to establish a few intermediate results that will aid us in the proof of our proposition.

Lemma 1 For $\tau > \left(\frac{u_N}{u_S}\right)^{\frac{\alpha}{1-\alpha}}$, the only equilibrium that features neither specialization of at least one Northern city in management services (M) nor the clustering of the management services sector in one of the Northern cities is the symmetric equilibrium with identical Northern cities (i.e. same population, same skill share, identical industrial structure)

Proof: Let us assume that there exists an equilibrium in which neither of the Northern cities is specialized in management services, and the management services sector is not completely clustered in one of the Northern cities. Thus such a candidate equilibrium could have a configuration of the following type in the North:

- $N1$: producing M and one or multiple tasks (either 1 or 2, or both)
- $N2$: producing M and one or multiple tasks (either 1 or 2, or both)

First, let us note that in any equilibrium with the above type of configuration, it would have to be the case that the price of land in the two Northen cities would have to be the same, $r_{N1} = r_{N2} = r_N$. This is the case because the two Northern cities are assumed to be ex-ante identical and both task producing activities (task 1 and task 2) are assumed to be free from agglomeration/ localization economies.
Secondly, we will show that in a candidate equilibrium with the above configuration, it will always be the case that if any Northern location produces task 1,

then task 2 cannot be produced in the South. We will show this by contradiction. Consider an equilibrium with the configuration described above in which at least one of the Northern locations produces task 1, and task 2 is produced in the South. Given that in the candidate equilibrium the Northern locations would have the same price of land (and hence the same production costs for any of the tasks) we can write:

$$c_N(1) \leq c_{S2}(1) \tag{51}$$

plugging in the relevant expressions for the cost functions for task 1 at the locations $S2$ and any of the Northern locations and simplifying yields the inequality:

$$\frac{r_N}{r_{S2}} \leq \left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{52}$$

From the conjecture that task 2 is produced both in the South and at one of the Northern locations we would have that:

$$c_{S2}(2) = c_{N2}(2) \tag{53}$$

where the equality sign derives from the result (which will be established in a subsequent lemma) that whenever activity 2 is optimally produced in the South, it will also be produced in the South's more advanced city $S2$.
Plugging the relevant expressions for the costs functions in equation (53) above - from equations (19), (10) and (11) - yields:

$$\left[\frac{1}{\gamma}\left(\frac{1}{A^\rho}\frac{u_S}{\alpha(1-\epsilon)}\right)^\alpha\left(\frac{p_N^M\tau}{1-\alpha}\right)^{1-\alpha}\right]^\gamma\left[\frac{1}{1-\gamma}\left(\frac{1}{A}\frac{u_S}{\beta}\right)^\beta\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma} =$$

$$= \left[\frac{1}{\gamma}\left(\frac{1}{A^\rho}\frac{u_N}{\alpha(1-\epsilon)}\right)^\alpha\left(\frac{p_N^M}{1-\alpha}\right)^{1-\alpha}\right]^\gamma\left[\frac{1}{1-\gamma}\left(\frac{1}{A}\frac{u_N}{\beta}\right)^\beta\left(\frac{r_N}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma}$$

which after some simplification yields

$$\left(u_S^\alpha\tau^{1-\alpha}\right)^\gamma\left(u_S^\beta r_{S2}^{1-\beta}\right)^{1-\gamma} = u_N^{\alpha\gamma}\left(u_N^\beta r_N^{1-\beta}\right)^{1-\gamma} \tag{54}$$

Further simplifying and denoting:

$$KT = \left[\left(\frac{u_S}{u_N}\right)^\alpha\tau^{1-\alpha}\right]^\gamma > 1 \tag{55}$$

where the inequality is established by noting the parameter restriction in the statement of the Lemma, we finally obtain:

$$1 < KT = \left[\left(\frac{u_N}{u_S}\right)^\beta\left(\frac{r_N}{r_{S2}}\right)^{1-\beta}\right]^{1-\gamma} < 1 \tag{56}$$

where the final inequality is established by noting the result obtained in equation (52).

Equation (56) reveals a contradiction, which establishes the result that task 1 being produced in the North simultaneously with task 2 production in the South, is incompatible with an equilibrium of the conjectured configuration.
But then an equilibrium of the conjectured configuration in which any of the Northern locations produces task 1 cannot occur either. This is because in such an equilibrium the previous proof establishes that the South will not produce task 2, which means that the South will be fully specialized in task 1 production. But if this is the case, then the parameter restriction outlined in equation (7) guarantees that when the South becomes fully specialized in task 1 it then takes over the entire production of task 1 (in effect equation (7) guarantees that the task 1 sector is small enough such that it fits completely in the South if the South is engaged in no other activity).

Taking into account the above discussion, the only possibility for an equilibrium of the proposed configuration to exist is that both Northern cities produce both management services and task 2. Again, by the same argument as before, it will be the case that $r_{N1} = r_{N2}$. Given this, it has tow be the case in a candidate equilibrium that exactly half of the management services sector locates in each of the Northern cities (otherwise one city would provide better rents and greater agglomeration benefits for management services producers). But then given that the cities need to have the same rental rate in equilibrium, then they need to attract the same fraction of the task 2 production sector. This concludes our proof, since we are now left with only the possibility of two identical Northern cities: the cities in the candidate equilibrium have the same industrial structure, population, skill share and land prices.

Definition 1 **- Stability:** We will call an equilibrium stable if it survives a deviation of a positive but small mass of management services firms ϕ that move from one Northern city to the other. A deviation is considered small if the number of firms deviating from one northern city to the other does not inverse the locations'rankings as producers of management services.

Lemma 2 If the agglomeration force is strong enough and increases rapidly enough as a location gains the majority market share in management services, namely if:

$$\frac{F'\left(\frac{1}{2}\right)}{F\left(\frac{1}{2}\right)} > \frac{2\gamma(1-\alpha)(1-\gamma')}{[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]} \tag{57}$$

then any equilibrium featuring symmetric cities in the North is unstable in the sense established by Definition 1 above.
Proof: Totally differentiating the expression for the costs of producing management services in the two cities in the symmetric equilibrium and imposing the condition that the cost of producing management services in the city receiving management production activities decline relative to the city losing management services activity establishes the above result.

In what follows we will maintain the restrictions imposed by Lemma 2 to complete the proof of proposition 1. Proposition 1 establishes the configuration of

the equilibrium of interest (asymmetric and stable in the sense of Definition 1 above) for high enough communication costs. The purpose of Proposition 1 is to delineate the status-quo in a pre-globalization world. Intuitively, for high enough communication costs, the South will be unable to undertake task 2 production, and given its assumed extreme disadvantage in the production of management services it will specialize completely in task 1 production. But then, given the parametric restriction given by equation (7) we know that the South will capture the entire wold production of task 1. Thus in searching for equilibria that could prevail for communication costs that are high enough to preven the South from engaging in any task 2 production, we need to restrict attention to candidate equilibria in which the South is fully specialized in task 1, and undertakes the entire world production of task 1.

Regarding the North, by the results of lemma 1 we have that any world equilibrium can induce one of the following types of equilibria in the North:

1. equilibria with symmetric (identical) Northern cities
2. equilibria with at least one of the Northen cities completely specialized in management services
3. equilibria the management services sector clustered in one of the Northern cities

Given that we are looking for asymmetric and stable equilibria we will ignore equilibria of the type 1. Also, it is easy to see that in candidate equilibria with very high transportation costs in which the North needs to house the entire task 2 production activity as well as the entire management services sector, equilibria of the type described in 2 above also cannot exist. We are then left with the possibility of equilibria of type 3.(it is easy to see that asymmetric equilibria of this type are stable in the sense of Definition 1).
To construct such equilibria we require allocation that induces an equilibrium of type 3 in the North while providing no incentive for deviation to the South by task 2 producers (task 1 producers are guaranteed by our parameter restrictions not to deviate, while management services firms face, by assumption, large North-South productivity differentials). A configuration that satisfies the requirements of a within country asymmetric equilibrium in the North is having city $N2$ concentrate the entire management services sector and also undertake some task 2 activity while city $N1$ is completely specialized in task 2 production, such that the two cities have the same land rental rates. In order for this candidate configuration to be a world equilibrium all we need to ensure is that task 2 producers have no incentive to deviate to the South. We thus require:

$$c_N(2) < c_{S2}(2) \tag{58}$$

expanding the above equation we obtain

$$\left[\frac{1}{\gamma}\left(\frac{1}{A^{\rho}}\frac{u_S}{\alpha(1-\epsilon)}\right)^{\alpha}\left(\frac{p_N^M\tau}{1-\alpha}\right)^{1-\alpha}\right]^{\gamma}\left[\frac{1}{1-\gamma}\left(\frac{1}{A}\frac{u_S}{\beta}\right)^{\beta}\left(\frac{r_{S2}}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma} <$$
$$\left[\frac{1}{\gamma}\left(\frac{1}{A^{\rho}}\frac{u_N}{\alpha(1-\epsilon)}\right)^{\alpha}\left(\frac{p_N^M}{1-\alpha}\right)^{1-\alpha}\right]^{\gamma}\left[\frac{1}{1-\gamma}\left(\frac{1}{A}\frac{u_N}{\beta}\right)^{\beta}\left(\frac{r_N}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma}$$

which after simplification yields the familiar expression:

$$\left(u_S^{\alpha}\tau^{1-\alpha}\right)^{\gamma}\left(u_S^{\beta}r_{S2}^{1-\beta}\right)^{1-\gamma} = u_N^{\alpha\gamma}\left(u_N^{\beta}r_N^{1-\beta}\right)^{1-\gamma} \tag{59}$$

which can be rewritten:

$$\tau^{\gamma(1-\alpha)} > \left(\frac{u_N}{u_S}\right)^{\alpha\gamma+\beta(1-\gamma)}\left(\frac{r_N}{r_{S2}}\right)^{(1-\beta)(1-\gamma)} \tag{60}$$

But in the conjectured equilibrium the land rental rates would be given by equations (42), (43) and (46). Plugging these equations in above yields

$$\tau^{\gamma(1-\alpha)} > \left\{\frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{2\frac{K_1}{1+K_1}a}\right\}^{(1-\beta)(1-\gamma)}\left(\frac{u_N}{u_S}\right)^{\alpha\gamma+\beta(1-\gamma)} \tag{61}$$

$$\tau > \left\{\frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{2\frac{K_1}{1+K_1}a}\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}}\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}} \tag{62}$$

Thus, if communication costs are high enough to satisfy equation (62) above, then the proposed configuration detailed in proposition 1 indeed represents a world equilibrium. Moreover, by the constructive argument provided by the proof above it is the only equilibrium configuration in the sense of Definition 1 outlined in this appendix. This concludes the proof of the main statement of Proposition 1. The other statements follow immediatelly: in the asymmetric equilibrium the advanced Sotuerh city ($S2$) displays higher population, higher land prices and higher output than its backward counterpart due to its productive amenity, but both cities have the same skill share as they produce the same type of output (with relative wages being fixed by the outside option, the skill share used at various locations will be fixed), whereas in the North the cities have the same land prices, but because of the higher density of employment and output in the management services sector, as well as the greater skill intensity of this sector, the "designated"advanced Northen city $N2$ displays greater population, skill share and output than its counterpart $N1$.

6.3 Discussion of Proposition 2

Proposition 2 establishes the existence and stability of equilibria of interest along an interval in which neither advanced city ($N2$ or $S2$) is completely specialized,

and also characterizes the comparative statics of the system when restricting the analysis to the equilibria of interest.
As communication costs fall below the threshold outlined in proposition 1, we expect the South to become increasingly competitive at producing task 2. In particular, the advanced Southern city $S2$ will become competitive in the production of task 2 before its companion backward city. This result is established in the next Lemma:

Lemma 3 In any equilibrium configuration it cannot be the case that city $S1$ engages in the production of task 2 before city $S2$ is completely specialized in task 2 production.

The proof proceeds by contradiction. Let us assume there exists an equilibrium configuration in which $S1$ houses task 2 producers before $S2$ is fully specialized in task 2. By our assumptions regarding the management services sector it has to be the case that in such an equilibrium $S2$ is still producing task 1. For this to be an equilibrium outcome it must be the case that:

$$c_{S2}(1) \leq c_{S1}(1) \tag{63}$$

where equality holds if $S1$ is also engaged in task 1 production. Plugging in the expressions of the relevant costs functions and simplifying yields, after some manupulations:

$$\frac{1}{A^{\beta}} r_{S2}^{1-\beta} \leq r_{S1}^{1-\beta} \tag{64}$$

On the other hand, the assumption that both cities produce task 2 in the equilibrium configuration requires that:

$$c_{S2}(2) = c_{S1}(2) \tag{65}$$

After some plugging in the expression for the cost functions and some manipulations, equation (65) above yields:

$$\frac{1}{A^{\rho\gamma\alpha}} \frac{1}{A^{\beta(1-\gamma)}} r_{S2}^{(1-\beta)(1-\gamma)} = r_{S1}^{(1-\beta)(1-\gamma)} \tag{66}$$

However it is easy to see that equations (66) and (64) are incompatible, which establishes a contradictions. This concludes the proof.

Thus, as the communication costs fall below the threshold T_{Max} outlined in proposition 1, the advanced Southern city will begin capturing task 2 activity. If the labor costs differential between the two countries is large enough (which we assume via the parameter restrictions) the movement of task 2 activities will continue until, gradually the advanced cities of both North and South will specialize into just one activity (i.e. $S2$ in task 2, $N2$ in M). However, it is not ex-ante clear in which order these specializations will occur. Under the parameter restriction imposed in equation (9) it will be the case that along the path of elimination of communication frictions, the skilled city of the South will

become completely specialized before its Northern advanced counterpart (the proof regarding the "timing"of specialization is available on request).
In what follows we will aim to determine the range of communication costs in which none of the advanced cities becomes completely specialized. As the upper boundary of this interval is given by T_{Max} in what follows we will aim to determine the lower boundary. The lower boundary of communication of this interval occurs when, in the asymmetric equilibrium, $S2$ becomes completely specialized in task 2 production while the land price differential between the two Southern city makes task 1 producers indifferent between the two Southern locations. This can be formally written

$$r_{S1} = \frac{(1-\beta)aY}{\overline{N}} \tag{67}$$

$$r_{S2} = K_1 r_{S1} \tag{68}$$

where the first condition comes from the fact that when $S2$ becomes completely specialized in task 2, $S1$ will carry the entire task 1 production sector, while the second equation comes from the indifference condition imposed on task 1 producers, with the constant K_1 carrying the same expression as before $K_1 = A^{\frac{\beta}{1-\beta}} > 1$. From $S2$'s complete specialization in task 2 we can write:

$$r_{S2}\overline{N} = (1-\beta)(1-\gamma)Y_{S2} \tag{69}$$

After a few simple manipulations we can obtain:

$$\frac{r_{S2}}{r_{S1}} = K_1 = \frac{(1-\gamma)Y_{S2})}{aY} \tag{70}$$

which yields:

$$Y_{S2} = \frac{aK_1 Y}{1-\gamma} \tag{71}$$

When specialization in $S2$ occurs we also have that:

$$Y_{S1} = aY \tag{72}$$

$$Y_{N1} + Y_{N2}^{(2)} + Y_{S2} = (1-a)Y \tag{73}$$

where $Y_{N2}^{(2)}$ represents the value of $N2$'s task 2 output. Combining (73) with (71) yields the following value of the task 2 output produced in the North at the moment of $S2$ specialization:

$$Y_{N2}^{(2)} + Y_{S2} = \frac{(1-a)(1-\gamma) - aK_1}{1-\gamma} Y \tag{74}$$

In the asymmetric equilibrium with specialized $S2$ it would also be the case that in the North we would have:

$$r_{N1}\overline{N} = (1-\beta)(1-\gamma)Y_{N1} \tag{75}$$

$$r_{N2}\overline{N} = (1-\beta)(1-\gamma)Y_{N2}^{(2)} + (1-\beta)(1-\gamma')Y_{N2}^{(M)} \tag{76}$$

where $Y_{N2}^{(M)}$ represents the value of $N2$'s output of management services. But given that the Northern advanced city is not yet specialized, it has to be the case that $r_{N1} = r_{N2} = r_N$. Moreover, the value of the management services output is given by:

$$Y_{N2}^{(M)} = \gamma(1-\alpha)(1-a)Y \tag{77}$$

Equating the expression on the RHS of (75) and (76) and plugging in (77) yields:

$$Y_{N1} - Y_{N2}^{(2)} = \frac{\gamma(1-\alpha)(1-a)(1-\gamma')}{1-\gamma}Y \tag{78}$$

Further, coupling equations (74) and (78) yields:

$$Y_{N1} = \frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')] - aK_1}{2(1-\gamma)}Y \tag{79}$$

From the fact that in the asymmetric equilibria of the type considered task 2 is produced in both $S2$ and $N1$ it must be the case that $c_{N1}(2) = c_{S2}(2)$. Expanding and simplifying this equality yields:

$$r_{N1} = r_N = G(\tau) r_{S2} \text{ where} \tag{80}$$

$$G(\tau) = \left(\frac{u_S}{u_N}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{(1-\beta)(1-\gamma)}} \tau^{\frac{\gamma(1-\alpha)}{(1-\beta)(1-\gamma)}} \tag{81}$$

But similarly we also have in equilibrium that:

$$r_N \overline{N} = (1-\beta)(1-\gamma)Y_{N1} \tag{82}$$

$$r_{S2} \overline{N} = (1-\beta)(1-\gamma)Y_{S2} \tag{83}$$

Thus, we can write (from (80), (82) and (83)):

$$\frac{r_N}{r_{S2}} = G(\tau) = \frac{Y_{N1}}{Y_{S2}} = \frac{(1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')] - aK_1}{2K_1 a} \tag{84}$$

Finally expanding the expression of $G(\tau)$ and solving for τ yields:

$$\tau^* = T_{spec1} = \left\{\frac{(1-a)\left[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')\right] - aK_1}{2K_1 a}\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} \left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}} \tag{85}$$

which gives us the expression for the lower bound of the interval of communication costs in which the asymmetric equilibria do not display specialization of the advanced cities.

Proving that along the interval described in proposition 2 the asymmetric equilibria exist and are stable in the sense of Definition 1, and moreover that they are the only stable equilibria involves a constructive argument completely analogous to the one undertaken in the proof of proposition 1. Thus we will continue our discussion of proposition 2 by proving the second part of the proposition which concerns the comparative statics.

Proposition 2 - Comparative Statics The asymmetric equilibria described in proposition 2 satisfy the following equations:

$$\left(\frac{p_1}{a}\right)^a \left(\frac{p_2}{1-a}\right)^{1-a} = 1 \tag{86}$$

$$c_{S2}(2) = c_{N1}(2) = c_{N2}(2) = p_2 \tag{87}$$

$$c_{S1}(1) = c_{S2}(1) = p_1 \tag{88}$$

Equation (86) can be rewritten:

$$p_2 = K p_1^{-\frac{a}{1-a}} \tag{89}$$

where $K = \left[a^a(1-a)^{1-a}\right]^{\frac{1}{1-a}} = (1-a)a^{\frac{a}{1-a}}$ From (87) we again get:

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

$$r_N = G(\tau) r_{S2} \text{ with}$$

$$G(\tau) = \underbrace{\left(\frac{u_S}{u_N}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{(1-\beta)(1-\gamma)}}}_{K_2} \tau^{\frac{\gamma(1-\alpha)}{(1-\beta)(1-\gamma)}}$$

$$r_{S2} = K_1 r_{S1}$$

Substituting $c_{S2}(2)$ for p_2 and $c_{S2}(1)$ for p_1 in (89) (substitutions that are appropriate given (87) and (88)), expanding the expressions of the relevant cost functions and simplifying yields:

$$K_3 {p_M^N}^{\gamma(1-\alpha)} \tau^{\gamma(1-\alpha)} r_{S2}^{(1-\gamma)(1-\beta)} = K_4 r_{S2}^{-(1-\beta)\frac{a}{1-a}} \tag{90}$$

Where K_3 and K_4 are constant terms that include parameters of the model, while p_N^M is given by:

$$p_M^N = \frac{1}{B_{Max}} \left(\frac{1}{A^\rho} \frac{u_N}{\gamma'(1-\epsilon)}\right)^{\gamma'} \left[\frac{1}{1-\gamma'} \left(\frac{1}{A}\frac{u_N}{\beta}\right)^{\beta} \left(\frac{r_N}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma'} \tag{91}$$

But p_M^N can also be written more concisely:

$$p_M^N = K_5 r_N^{(1-\beta)(1-\gamma')} \tag{92}$$

where K_5 is a constant that gathers all the parameters in the expression (91) above being given by:

$$K_5 = \frac{1}{B_{Max}} \left(\frac{1}{A^\rho} \frac{u_N}{\gamma'(1-\epsilon)}\right)^{\gamma'} \left[\frac{1}{1-\gamma'} \left(\frac{1}{A}\frac{u_N}{\beta}\right)^{\beta} \left(\frac{1}{1-\beta}\right)^{1-\beta}\right]^{1-\gamma'} \tag{93}$$

Substituting (80) and (81) into (92), and plugging the resulting expression into (90), yields, after several manipulations:

$$r_{S2} = K_6 \tau^{-\frac{\gamma(1-\alpha)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{(1-\gamma)(1-\beta)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}} \tag{94}$$

$$r_{S1} = \frac{K_6}{K_1} \tau^{-\frac{\gamma(1-\alpha)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{(1-\gamma)(1-\beta)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}} \tag{95}$$

$$r_N = K_2 K_6 \tau^{\frac{\gamma(1-\alpha)\left(\frac{a}{1-a}\right)}{(1-\gamma)(1-\beta)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}} \tag{96}$$

From the expressions above it is already clear that as τ declines, rental rates in the South will increase while those in the North will decrease. In order to proceed to make statements about population movements we have to determine the value of output in equilibrium at each location. From the equality of expenditure on land inputs and the income of landlords we get:

$$\begin{aligned} r_{S1}\overline{N} + r_{S2}\overline{N} + r_{N1}\overline{N} + r_{N2}\overline{N} = (1-\beta)aY + (1-\beta)(1-\gamma)(1-a)Y \\ + \gamma(1-\alpha)(1-\beta)(1-\gamma')(1-a)Y \end{aligned} \tag{97}$$

Rearranging we can write:

$$Y = \frac{(r_{S1} + r_{S2} + r_{N1} + r_{N2})\overline{N}}{(1-\beta)(1-\gamma)(1-a)\left[1 + \gamma(1-\alpha)\frac{1-\gamma'}{1-\gamma} + \frac{a}{(1-a)(1-\gamma)}\right]} \tag{98}$$

Taking into account (68) and that $r_{N1} = r_{N2} = r_N$ we can further rewrite:

$$Y = \frac{[2r_N + (1+K_1)r_{S1}]\overline{N}}{(1-\beta)(1-\gamma)(1-a)\left[1 + \gamma(1-\alpha)\frac{1-\gamma'}{1-\gamma} + \frac{a}{(1-a)(1-\gamma)}\right]} \tag{99}$$

Given that in equilibria in this interval equations like (82) will apply we can write:

$$Y_{N1} = \frac{r_N \overline{N}}{(1-\beta)(1-\gamma)} \tag{100}$$

$$Y_{S1} = \frac{r_{S1}\overline{N}}{1-\beta} \tag{101}$$

From (78) we have that:

$$Y_{N1} - Y_{N2}^{(2)} = \frac{\gamma(1-\alpha)(1-a)(1-\gamma')}{1-\gamma} Y$$

Combining the equation above with (100) yields, after some manipulations:

$$Y_{N2}^{(2)} = \frac{r_N[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}] - \gamma(1-\alpha)(1-\gamma')(1+K_1)r_{S1}}{(1-\beta)(1-\gamma)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}\overline{N} \tag{102}$$

We also have that:

$$Y_{N1} + Y_{N2}^{(2)} + Y_{S2}^{(2)} = (1-a)Y \tag{103}$$

Which allows us to determine $Y_{S2}^{(2)}$:

$$Y_{S2}^{(2)} = \frac{(1+K_1)r_{S1}[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')] - 2r_N\frac{a}{1-a}}{(1-\beta)(1-\gamma)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}\overline{N} \tag{104}$$

Finally, we have that:

$$Y_{S1} + Y_{S2}^{(1)} = aY \tag{105}$$

Which allows us to determine $Y_{S2}^{(1)}$:

$$Y_{S2}^{(1)} = \frac{2ar_N + r_{S1}\{aK_1 - (1-a)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]\}}{(1-\beta)(1-\gamma)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}\overline{N} \tag{106}$$

The value of the output of the management services sector is simply given by combining combining (77) and (99):

$$Y_{N2}^{M} = \frac{\gamma(1-\alpha)[2r_N + (1+K_1)r_{S1}]}{(1-\beta)(1-\gamma)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}\overline{N} \tag{107}$$

From the expressions of output values obtained above, it becomes immediately clear that the value of Y_{S1} increases as communication costs decline, while the value of Y_{N1} declines when communication frictions are reduced. Moving on to populations, these can be expressed as follows:

$$Pop_{S1} = \frac{\beta Y_{S1}}{u_S} = \frac{\beta}{1-\beta}r_{S1}\overline{N}u_S \tag{108}$$

$$Pop_{S2} = \frac{\beta Y_{S2}^{(1)}}{u_S} + \frac{\beta(1-\gamma)Y_{S2}^{(2)}}{u_S} + \frac{\alpha\gamma Y_{S2}^{(2)}}{u_S} \tag{109}$$

$$Pop_{N1} = \frac{\beta(1-\gamma)Y_{N1}}{u_N} + \frac{\alpha\gamma Y_{N1}}{u_N} \tag{110}$$

$$Pop_{N2} = \frac{\beta(1-\gamma)Y_{N2}^{(2)}}{u_N} + \frac{\alpha\gamma Y_{N2}^{(2)}}{u_N} + \frac{\beta(1-\gamma')Y_{N2}^{(M)}}{u_N} + \frac{\gamma' Y_{N2}^{(M)}}{u_N} \tag{111}$$

From our previous results regarding the paths of r_{S1} and r_N, it become immediately clear that as τ decreases, the population of $S1$ increases while that of $N1$ decreases. Taking the sum of $Y_{S2}^{(1)}$ (which is decreasing) and $Y_{S2}(M)$ (which is increasing) and differentiating yields us the result that the total value of location $S2$'s production increases as communication frictions are eased. Moreover, plugging the relevant expressions for outputs into (109) above and simplifying yields the expression:

$$Pop_{S2} = \frac{1}{u_S}\left[\frac{\beta}{1-\beta}\frac{r_{S1}\overline{N}[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]K_1}{[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]} + g(r_{S1}) + \alpha\gamma Y_{S2}(2)\right] \tag{112}$$

where $g(r_{S1})$ collects terms such that it is an increasing function of r_{S1}. As all the elements of the above expression increase as τ falls it is clear that Pop_{S2} also increases as international communication frictions are removed.
Finally we are ready to analize the evolution of the population of location $N2$. Substituting the relevant output expressions into(111) and collecting terms we can write:

$$Pop_{N2} = f_1(r_N) + f_2(r_{S1}) \tag{113}$$

$$f_1(r_N) = \frac{r_N}{u_N} \overbrace{\frac{\alpha\gamma + \beta(1-\gamma)}{(1-\beta)[(1-\gamma) + \gamma(1-\alpha)(1-\gamma') + \frac{a}{1-a}]}\overline{N}}^{K_7} \left\{1 - \gamma(1-\alpha)\frac{1-\gamma'}{1-\gamma} + \frac{a}{(1-a)(1-\gamma)} + 2\gamma(1-\alpha)t\right\} \tag{114}$$

$$f_2(r_{S1}) = (1+K_1)\frac{r_{S1}}{u_N} \overbrace{\frac{\alpha\gamma + \beta(1-\gamma)}{(1-\beta)[(1-\gamma) + \gamma(1-\alpha)(1-\gamma') + \frac{a}{1-a}]}\overline{N}}^{K_7} \left\{\gamma(1-\alpha)t - \frac{\gamma(1-\alpha)(1-\gamma')}{1-\gamma}\right\} \tag{115}$$

where K_7 is a constant summarizing the indicated expression and t is given by:

$$t = \frac{\gamma' + \beta(1-\gamma')}{\alpha\gamma + \beta(1-\gamma)} > 1 \tag{116}$$

Partially differentiationg (94) and (95) and taking the ratio of the partial derivatives yields:

$$\frac{\frac{\partial r_{S1}}{\partial \tau}}{\frac{\partial r_N}{\partial \tau}} = -\frac{1-a}{a}[(1-\gamma) + \gamma(1-\alpha)(1-\gamma')]K_1^{-1}\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{(1-\beta)(1-\gamma)}} \tau^{-\frac{\gamma(1-\alpha)}{(1-\beta)(1-\gamma)}} \tag{117}$$

Thus we will have that:

$$\frac{\partial Pop_{N2}}{\partial \tau} = f_1'(r_N)\frac{\partial r_N}{\partial \tau} + f_2'(r_{S1})\frac{\partial r_{S1}}{\partial \tau} \tag{118}$$

Which can be rewritten:

$$\frac{\partial Pop_{N2}}{\partial \tau} = \frac{\partial r_N}{\partial \tau}\left\{K_7\left\{1 - \gamma(1-\alpha)\frac{1-\gamma'}{1-\gamma} + \frac{a}{(1-a)(1-\gamma)} + 2\gamma(1-\alpha)t\right\} - (1+K_1)K_7\left\{\gamma(1-\alpha)t - \frac{\gamma(1-\alpha)(1-\gamma')}{1-\gamma}\right\}\frac{1-a}{a} [(1-\gamma) + \gamma(1-\alpha)(1-\gamma')]K_1^{-1}\left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{(1-\beta)(1-\gamma)}} \tau^{-\frac{\gamma(1-\alpha)}{(1-\beta)(1-\gamma)}}\right\} \tag{119}$$

As $\frac{\partial r_N}{\partial \tau} < 0$ the sign of the expression on the RHS of (119) will be determined by the sign of the expression in the curly brackets. The expression in the curly brackets can be shown, after some manipilations, to be negative (and thus cause the whole RHS to be pozitive) when τ obeys the inequality:

$$\tau < \left\{ \frac{\frac{1+K_1}{K_1}\left\{\gamma(1-\alpha)t - \frac{\gamma(1-\alpha)(1-\gamma')}{1-\gamma}\right\}\frac{1-a}{a}[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{1-\gamma(1-\alpha)\frac{1-\gamma'}{1-\gamma}+\frac{a}{(1-a)(1-\gamma)}+2\gamma(1-\alpha)t} \right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} \times \left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}} \quad (120)$$

Conversely, if the inequality above is violated, a reduction in τ leads to a reduction in the population of $N2$. Ex-ante it is unclear whether the expression on the RHS lies in the interval between T_{spec1} and T_{Max}. What is easy to show is that the RHS of (120) is smaller than T_{Max} such that at least towards the upper end of the interval $N2$ will display population losses. If the RHS of (120) is greater than T_{spec1} (which will happen, for instance if a is small enough) then at some point along the interval covered by proposition 2 the fortunes of $N2$ will reverse and it will start posting population gains. If on the other hand this does not happen, then $N2$ will post population losses along the entire interval covered by proposition 2.

Similarly, one can show that the behaviour of Y_{N2} (total output produced in $N2$) will largely mirror that of Pop_{N2}: it is guaranteed to decline in a neqighbourhood of T_{Max} but its behaviour is ambigous over the whole interval. Moreover, along the entire interval, it is clear that world urbanization increases, as overall world GDP grows, which means that the worldwide wage bill also grows. Given that this is accompanied by a substitution of "high paid"Northern workers with "low paid"Southern workers, it is clear that the total number of workers employed in the formal sector in the world economy increases which is equivalent ot rising urbanization. Moreover from the pattern of shifting industrial locations it becomes clear that as τ declines, the industrial composition of locations changes such that: $\frac{H_{S1}}{L_{S1}}$ =constant , $\frac{H_{S2}}{L_{S2}} \uparrow$, $\frac{H_{N1}}{L_{N1}}$ =constant, $\frac{H_{N2}}{L_{N2}} \uparrow$

We will conclude this section with a proof of the claim that along the interval covered by proposition 2, reductions in international communication costs are accompanied by faster population increases in the South's advanced city $S2$ relative to the backward $S1$. Rewriting some of the expressions derived above we have

$$Pop_{S1} = \frac{\beta Y_{S1}}{u_S} = \frac{\beta}{1-\beta} r_{S1} \overline{N} u_S$$

$$Pop_{S2} = \frac{\beta Y_{S2}^{(1)}}{u_S} + \frac{\beta(1-\gamma)Y_{S2}^{(2)}}{u_S} + \frac{\alpha\gamma Y_{S2}^{(2)}}{u_S}$$

Taking the ratio of the populations of the two cities we obtain:

$$\frac{Pop_{S2}}{Pop_{S1}} = \frac{Y_{S2}^{(1)}}{Y_{S1}} + \frac{\alpha\gamma + \beta(1-\gamma)}{\beta}\frac{Y_{S2}^{(1)}}{Y_{S1}} \quad (121)$$

Substituting for the relevant outputs in (121), simplifying and gathering terms yields:

$$\frac{Pop_{S2}}{Pop_{S1}} = CT_1 + \frac{\alpha\gamma + \beta(1-\gamma)}{\beta} CT_2 + \\ + \underbrace{\frac{\alpha}{\beta}\gamma \frac{2a}{(1-a)(1-\gamma)[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}}_{CT_3} \frac{r_N}{r_{S1}} \quad (122)$$

Where the CT terms are constants collecting expressions containing only parameters of the model. Differentiating the expression above with respect to τ yields:

$$\frac{\partial \frac{Pop_{S2}}{Pop_{S1}}}{\partial \tau} = -CT_3 \frac{\partial \frac{r_N}{r_{S1}}}{\partial \tau} > 0 \quad (123)$$

which concludes our proof regarding the differential growth of Southern cities.

6.4 Discussion of Proposition 3

Proposition 3 describes the equilibria of interest and the relevant comparative statics for the range of communication costs that appears between the threshold at which $S2$ becomes specialized in task 2 (which we called T_{spec1} and the threshold at which $N2$ becomes fully specialized in management services. As in the discussion on Proposition 2 we will begin by deriving the lower bound of the interval.

Via a continuity argument it is clear that the threshold that marks $N2$ specialization will occur when, in a configuration with fully specialized $N2$, task 2 producers are indifferent between location in $N1$ and $N2$, and thus the rental rates of the two cities are still equal. Thus we have (in such an equilbrium):

$$r_{S1}\overline{N} = (1-\beta)aY \quad (124)$$

$$r_{S2}\overline{N} + r_{N1}\overline{N} = (1-\beta)(1-\gamma)(1-a)Y \quad (125)$$

$$r_{N2}\overline{N} = \gamma(1-\alpha)(1-\beta)(1-\gamma')(1-a)Y \quad (126)$$

$$r_{N1} = G(\tau) r_{S2} \quad (127)$$

Plugging (127) into (125) yields, after some manipulations:

$$r_{S2} = \frac{1}{1+G(\tau)}(1-\beta)(1-\gamma)(1-a)\frac{Y}{\overline{N}} \quad (128)$$

$$r_{N1} = \frac{G(\tau)}{1+G(\tau)}(1-\beta)(1-\gamma)(1-a)\frac{Y}{\overline{N}} \quad (129)$$

$$r_{N2} = \gamma(1-\alpha)(1-\beta)(1-\gamma')(1-a)\frac{Y}{\overline{N}} \quad (130)$$

Finally imposing $\frac{r_{N2}}{r_{N1}} = 1$, substituting for r_{N1} and r_{N2} from above and solving for τ gives us:

$$\tau^{**} = T_{spec2} = \left\{ \frac{\gamma(1-\alpha)(1-\gamma')}{(1-\gamma)-\gamma(1-\alpha)(1-\gamma')} \right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} \left(\frac{u_N}{u_S} \right)^{\frac{\alpha\gamma+\beta(1-\gamma)}{\gamma(1-\alpha)}} \tag{131}$$

Again, we will refer the reader to the constructive argument employed in the proof of proposition 1 and omit the proof that along the interval of communication costs covered by proposition 3 equilibria of interest exist and are stable, and moreover, there are no other stable equilibria. As in the discussion in the previous section regarding proposition 2, we will focus here on showing the comparative static results. In an asymmetric equilibrium of the type described in the first part of proposition 3 we have that:

$$Y_{S1} = aY \tag{132}$$

$$Y_{S2} + Y_{N1} + Y_{N2}^{(2)} = (1-a)Y \tag{133}$$

$$r_{S2}\overline{N} = (1-\beta)(1-\gamma)Y_{S2} \tag{134}$$

$$r_{N1}\overline{N} = (1-\beta)(1-\gamma)Y_{N1} \tag{135}$$

$$r_{N2}\overline{N} = (1-\beta)(1-\gamma)Y_{N2}^{(2)} + \gamma(1-\alpha)(1-a)(1-\beta)(1-\gamma')Y \tag{136}$$

$$r_{N1} = r_{N2} = r_N \tag{137}$$

$$r_{N1} = G(\tau)r_{S2} \Rightarrow Y_{N1} = G(\tau)Y_{S2} \tag{138}$$

From (135) − (137) we again obtain:

$$Y_{N1} - Y_{N2}^{(2)} = \frac{\gamma(1-\alpha)(1-a)(1-\gamma')}{1-\gamma}Y \tag{139}$$

With the aid of expressions (138) and (139) we can rewrite (133) solely in terms of Y_{N1} and after some manipulations obtain:

$$Y_{N1} = \frac{(1-a)Y[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{(1-\gamma)\left[2+\frac{1}{G(\tau)}\right]} \tag{140}$$

From (138) we can then write:

$$Y_{S2} = \frac{(1-a)Y[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{(1-\gamma)\left[2G(\tau)+1\right]} \tag{141}$$

Then, from (139) we get:

$$Y_{N2}^{(2)} = \frac{(1-a)Y}{1-\gamma}\left\{ \frac{(1-a)Y[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}{\left[2+\frac{1}{G(\tau)}\right]} - \gamma(1-\alpha)(1-\gamma') \right\} \tag{142}$$

While $Y_{N2}^{(M)}$ is simply given by:

$$Y_{N2}^{(M)} = \gamma(1-\alpha)(1-a)Y \tag{143}$$

Moreover, equilibria of interest are defined by the equations:

$$p_2 = Kp_1^{-\frac{a}{1-a}} \tag{144}$$

$$c_{S1}(1) = p_1 \tag{145}$$

$$c_{S2}(2) = c_{N1}(2) = c_{N2}(2) = p_2 \tag{146}$$

Substituting c_{S2} for p_2 and c_{S1} for p_1 in (144), expanding the expressions of the cost functions and simplifying yields:

$$K_8 {p_M^N}^{\gamma(1-\alpha)} \tau^{\gamma(1-\alpha)} r_{S2}^{(1-\gamma)(1-\beta)} = K_9 r_{S1}^{-(1-\beta)\frac{a}{1-a}} \tag{147}$$

Where as before K_8 and K_9 are constants that collect term comprised of parameters. From dividing (134) by $r_{S1}\overline{N} = (1-\beta)aY$ we obtain:

$$\frac{r_{S2}}{r_{S1}} = \underbrace{\frac{1-a}{a}[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')]}_{K_{10}} \frac{1}{2G(\tau)+1} \tag{148}$$

Substituting (138) in (91) and then plugging the resulting expression for p_M^N into (147), and then using (148) to substitute for r_{S2} in the resulting expression, allows us, after several manipulations, to solve for r_{S1}

$$r_{S1} = K_{11}\left[2+\frac{1}{G(\tau)}\right]^{\frac{(1-\gamma)+\gamma(1-\alpha)(1-\gamma')}{(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}}} \tag{149}$$

We also have that:

$$r_{S2} = K_{10}\frac{1}{2G(\tau)+1} r_{S1} \tag{150}$$

$$r_N = G(\tau) r_{S2} = K_{10}\frac{1}{2+\frac{1}{G(\tau)}} r_{S1} \tag{151}$$

Finally, rewriting (151) we have:

$$r_N = K_{10}K_{11}\left[2+\frac{1}{G(\tau)}\right]^{\frac{-\frac{a}{1-a}}{(1-\gamma)+\gamma(1-\alpha)(1-\gamma')}} \tag{152}$$

From the expressions above it can be seen that:

$$\begin{aligned} &\tau\downarrow \Rightarrow r_{S1}\uparrow, r_{S2}\uparrow, \frac{r_{S2}}{r_{S1}}\uparrow, r_{N1} = r_{N2}\downarrow, Y\uparrow, Y_{S1}\uparrow, Y_{S2}\uparrow, Y_{N1}\downarrow, \\ &\frac{H_{S1}}{L_{S1}} = \text{constant}, \frac{H_{S2}}{L_{S2}} = \text{constant}, \frac{H_{N1}}{L_{N1}} = \text{constant}, \frac{H_{N2}}{L_{N2}}\uparrow, Y_{N2}^{(2)}\downarrow, Y_{N2}^{(M)}\uparrow \end{aligned} \tag{153}$$

Moving on to the population measures, in equilibrium in the interval covered by proposition 3 we will have:

$$Pop_{S1} = \frac{\beta Y_{S1}}{u_S} \tag{154}$$

$$Pop_{S2} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_S} Y_{S2} \tag{155}$$

$$Pop_{N1} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} Y_{N1} \tag{156}$$

$$Pop_{N2} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} Y_{N2}^{(2)} + \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} Y_{N2}^{(M)} \tag{157}$$

From the above expressions and the previous results it becomes clear that as communication frictions are reduced we will have that:$Pop_{S1} \uparrow$,$Pop_{S2} \uparrow$, with Pop_{S2} growing faster than Pop_{S1}, $Pop_{N1} \downarrow$
Finally, let us analyze the evolution of Pop_{N2}. Rewriting (157) we have:

$$Pop_{N2} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} \left\{ Y_{N2}^{(2)} + Y_{N2}^{(M)} \right\} \tag{158}$$

$$Pop_{N2} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} \frac{(1-a)Y}{1-\gamma} \left\{ \frac{(1-a)Y[(1-\gamma) + \gamma(1-\alpha)(1-\gamma')]}{\left[2 + \frac{1}{G(\tau)}\right]} - \gamma(1-\alpha)(1-\gamma') \right\} + \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} t\gamma(1-\alpha)(1-a)Y \tag{159}$$

Differentiating expression (159) with respect to τ gives us, after several manipulations that $\frac{\partial Pop_{N2}}{\partial \tau} > 0$ iff:

$$\tau < \left\{ \frac{(1-a)\gamma(1-\alpha)[t(1-\gamma) - (1-\gamma')]}{a - 2(1-a)\gamma(1-\alpha)[t(1-\gamma) - (1-\gamma')]} \right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} \left(\frac{u_N}{u_S} \right)^{\frac{\alpha\gamma + \beta(1-\gamma)}{\gamma(1-\alpha)}} \tag{160}$$

With the converse result holding if the above inequality is violated. As in the previous result we see that the implications of the comparative statics for $N2$ are ambigous, with $N2$ potentially increasing in population across the interval, decreasing at first in population and then increasing, or, in the case of extreme parameter values, decreasing in population along the entire interval. However, for a small enough and α not too large we will have that city $N2$ will start to grow along this interval (indeed potentially along the entire interval). Total output in $N2$ will largely follow the trajectory of its population. As in the previous section, reductions in transportation costs are guaranteed to result in increases in world urbanization.

6.5 Discussion of Proposition 4

As in the previous sections the discussion of this section will focus on the comparative static statements in the proposition. The proof of existence of stable

equilibria in proposition 4 proceeds by a similar argument as before. Note that proposition 4 is weaker than the previous results as it does not guarantee uniqueness of stable equilibria. However, with further restrictions this result could be re-established.
In an equilibrium of the type described in proposition 4 we will have that:

$$r_{S1}\overline{N} = (1-\beta)aY \tag{161}$$
$$Y_{S2} + Y_{S1} = (1-a)Y \tag{162}$$
$$r_{S2}\overline{N} = (1-\beta)(1-\gamma)Y_{S2} \tag{163}$$
$$r_{N1}\overline{N} = (1-\beta)(1-\gamma)Y_{N1} \tag{164}$$
$$r_{N2}\overline{N} = (1-\beta)(1-\gamma')Y_M \tag{165}$$
$$r_{N1} < r_{N2} \tag{166}$$
$$r_{N1} = G(\tau)r_{S2} \tag{167}$$
$$r_{N2}\overline{N} + r_{N1}\overline{N} = (1-\beta)(1-\gamma)(1-a)Y \tag{168}$$
$$c_{S1}(1) = p_1 \tag{169}$$
$$c_{S2}(2) = c_{N1}(2) = p_2 \tag{170}$$
$$p_2 = Kp_1^{-\frac{a}{1-a}} \tag{171}$$

Again, by substituting relevan cost functions in (171), expanding and then simplifying we obtain:

$$p_M^{N\,\gamma(1-\alpha)}\tau^{\gamma(1-\alpha)}r_{S2}^{(1-\gamma)(1-\beta)} = K_{12}r_{S1}^{-(1-\beta)\frac{a}{1-a}} \tag{172}$$

After substituting for p_M^N and simplifying we obtain:

$$r_{N2}^{\gamma(1-\alpha)(1-\beta)(1-\gamma')}\tau^{\gamma(1-\alpha)}r_{S2}^{(1-\beta)(1-\gamma)} = K_{13}r_{S1}^{-(1-\beta)\frac{a}{1-a}} \tag{173}$$

From (167) and (162) − (164) we have that:

$$Y_{S2} = \frac{1}{1+G(\tau)}(1-a)Y \tag{174}$$
$$Y_{N1} = \frac{G(\tau)}{1+G(\tau)}(1-a)Y \tag{175}$$

Making use of (174) and (175) above, as well as (161) and (163) − (165) we can write:

$$r_{S2} = \frac{1-a}{a}(1-\gamma)\frac{1}{1+G(\tau)}r_{S1} \tag{176}$$
$$r_{N2} = \frac{1-a}{a}\gamma(1-\alpha)(1-\gamma')r_{S1} \tag{177}$$

Substituting (176) and (177) in (173) finally allows us to solve for r_{S1}:

$$r_{S1} = K_{14}\left[1+\frac{1}{G(\tau)}\right]^{\frac{1-\gamma}{[(1-\gamma)+\gamma(1-\alpha)(1-\gamma')+\frac{a}{1-a}]}} \tag{178}$$

Thus from the expressions above it becomes clear that:$\tau \downarrow \Rightarrow G(\tau) \downarrow \Rightarrow r_{S1} \uparrow$, $r_{S2} \uparrow$, $\frac{r_S 2}{r_S 1} \uparrow$, $r_{N1} \downarrow$,$r_{N2} \uparrow$,$Y \uparrow$, $Y_{S1} \uparrow$,$Y_{S2} \uparrow$, $Y_{N1} \downarrow$, $Y_{N2} \uparrow$,$\frac{H_{S1}}{L_{S1}}$ =constant ,$\frac{H_{S2}}{L_{S2}}$ =constant,$\frac{H_{N1}}{L_{N1}}$ =constant, $\frac{H_{N2}}{L_{N2}}$ =constant, world urbanization $\uparrow$
Moving to the populations, in an asymmetric equilibrium as the one described in proposition 4 we will have that:

$$Pop_{S1} = \frac{\beta Y_{S1}}{u_S} \tag{179}$$

$$Pop_{S2} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_S} Y_{S2} \tag{180}$$

$$Pop_{N1} = \frac{\alpha\gamma + \beta(1-\gamma)}{u_N} Y_{N1} \tag{181}$$

$$Pop_{N2} = \frac{\gamma' + \beta(1-\gamma')}{u_N} Y_{N2} \tag{182}$$

Combining the expressions above with our previous results we obtain:

$$\tau \downarrow \Rightarrow Pop_{S1} \uparrow, Pop_{S2} \uparrow, Pop_{N1} \downarrow, Pop_{N2} \uparrow \tag{183}$$

Which concludes the proof of the comparative static results in Proposition 4.

6.6 Discussion of Proposition 5

Proposition 5 explores the conditions under which there can be "overtaking"along the global supply chain, with the skilled city of the South developing an industrial composition that is more skill intensive than that of the backward Northern city. In a sense, overtaking can be thought to already take place at the threshold τ^{***} when the price of the "advanced input composite"composed by skilled labor and management services becomes lower in the advanced Southern city relative to the backward Northen city (and hence the backward Northern city only remains competitive in the production of task 2 as a result of its depressed land prices). However the results of this overtaking will not be observable until the land prices of the backward Northern city $N1$ become so depressed such as to allow $N1$ to become competitive in the production of the least skill intensive good/ task. Thus the condition we require for overtaking to become observable is:

$$c_{N1}(1) = c_{S1}(1) \tag{184}$$

which, after some manipulations implies:

$$\frac{r_{N1}}{r_{S1}} = \left(\frac{A u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{185}$$

Via a continuity argument, it is clear that the threshold for observable overtaking will occur when equation (185) above holds, while $S1$ still contains the entire task 1 production sector. Thus in the threshold asymmetric equilibrium

of interest we will have that:

$$r_{S1}\overline{N} = (1-\beta)aY \tag{186}$$

$$Y_{S2} + Y_{N1} = (1-a)Y \tag{187}$$

$$r_{S2}\overline{N} = (1-\beta)(1-\gamma)Y_{S2} \tag{188}$$

$$r_{N1}\overline{N} = (1-\beta)(1-\gamma)Y_{N1} \tag{189}$$

$$r_{N2}\overline{N} = (1-\beta)(1-\gamma')Y_{N2} \tag{190}$$

$$r_{N1} = G(\tau)r_{S2} \tag{191}$$

$$r_{S2}\overline{N} + r_{N1}\overline{N} = (1-\beta)(1-\gamma)(1-a)Y \tag{192}$$

From (191) and (192) we obtain:

$$Y_{S2} = \frac{1}{1+G(\tau)}(1-a)Y \tag{193}$$

$$Y_{N1} = \frac{G(\tau)}{1+G(\tau)}(1-a)Y \tag{194}$$

Thus we can write:

$$\frac{r_{N1}}{r_{S1}} = \frac{1-a}{a}(1-\gamma)\frac{G(\tau)}{1+G(\tau)} = \left(\frac{Au_S}{u_N}\right)^{\frac{\beta}{1-\beta}} \tag{195}$$

Solving the equation (195) gives us a candidate threshold for observable overtaking:

$$\underline{\tau}^c = \left\{\frac{a}{1-a}\frac{K_1}{1-\gamma}\left[\left(\frac{u_S}{u_N}\right)^{\frac{\beta}{1-\beta}} + \left(\frac{u_N}{u_S}\right)^{\frac{\alpha\gamma}{(1-\beta)(1-\gamma)}}\right]\right\}^{\frac{(1-\beta)(1-\gamma)}{\gamma(1-\alpha)}} \tag{196}$$

If $\underline{\tau}^c < 1$ then the interval described by proposition 5 does not exist and the characterization of the path followed by the economic geography of the world as communication frictions are gradually reduced ends with Proposition 4. If on the other hand $\underline{\tau}^c > 1$, then the interval covered by proposition 5 is nonempty. Then observable overtaking can occur, and the economic geography of the world economy will behave as detailed in Proposition 5. The comparative static results can be established analogously to the previous sections. The main change in the comparative statics is that the unskilled cities of the two countries begin competing with each other they both decline, while the skilled cities of boh countrie continue to grow along all measures of urban success.

6.7 Discussion: What if the exogenous differences between the two Southern cities are not very big/important?

If the differences in the productive amenity between the two Southern cities are not very large (A is small enough) or not very important (ρ is small) then

our model will yield non-monotonic predictions for the South. Thus, as communication costs decrease, the South will witness a divergence stage, when the advanced Southern city grows faster in terms of population, displays skill divergence or divergence in land prices relative to the backward city. However, after a point, a convergence stage begins, with the two cities growing their land price at the same rate, but the backward city growing its population faster than the advanced city and closing the skills gap. Obviously a lesser relative productive limitation of $S2$, will also translate into increased overall competitiveness of the South, thus increasing the range of communication costs for which $N2$ becomes fully specialized in M, and futher deteriorates the vulnerability to foreign competition of $N1$.

6.8 Discussion: Location of Management Services

The arguments made in the paper rest critically on the management services sector locating in the South. In this section I will aim to argue that the assumptions made in the body of the paper are sufficient to guarantee this. The main concern is that as long as the South's productivity in performing management services tasks is not 0, a suboptimal equilibrium could emerge in which the entire sector is clustered in one of the Southern locations. This type of equilibrium could perhaps be sustained by beliefs by firms that no one in the North will acquire education, such that it becomes impossible to produce tasks that require skilled workers in the North. However, I will argue that if the productivity differential between N and S in management services is high enough, such a candidate equilibrium cannot be sustained. In particular if the North's productivity advantage in management services outweighs the benefits of complete agglomeration, then a single management services producer, by deviating, can upset the suggested candidate equilibrium. This is because while firms may be infinitesimal in equilibrium, they can acquire positive mass out of the equilibrium path. Thus, in the suggested alternative equilibrium configuration, a single firm could deviate from the Southern cluster and locate in the North. There it could offer to pay workers a skilled wage that would break their indifference between acquiring and not acquiring skills, and with a sufficiently $N-S$ productivity differential in management services still produce the management services cheaper than the firms remaining in the cluster. Moreover, via a deviation of this type, a single firm can capture the entire management services sector, thus upsetting the candidate equilibrium described above. Thus, the assumptions made in the paper are sufficient to guarantee that in equilibrium the management services sector locates in the North.