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# Gates, hubs and urban primacy in Sub-Saharan Africa

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# Gates, hubs and urban primacy in Sub-Saharan Africa

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**Abstract**

We investigate the impact of changes in international trade and domestic transport costs on the internal geography of a domestic economy linked to the rest of the World through a hub. We address that issue by developing two three regions model, namely a version of the Footlose Entrepreneur and a model à la Ottaviano et al. (2002). One region represents the rest of the World, while the two others compose the domestic economy. One region of the Domestic economy, the hub, exhibits a 'geographical advantage' in terms of easier access to the rest of the World. We find the standard result that decreases in transports and trade costs raise the likelihood of agglomeration in the domestic economy. However, high interregional transport may induce partial agglomeration in the hinterland even in case of trade integration. Therefore depending on the level of transportation costs, hinterland remoteness may not be a locational 'disadvantage' as Behrens et al. (2007) pointed out.

**Keywords**: economic geography, urban primacy, hub, developing countries.

**JEL Classification**: D58, F12, F15, R12

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# 1 Introduction

Sub-Saharan Africa (henceforth, SSA) faces an historically unprecedented absolute rate of urban growth. With an urban population growth rate averaging almost 5 percent per year, its urban population is expected to double every 15 years. Yet, while rates of urban population growth of cities of SSA remain the highest of the World, urbanization in that region is taking place in a context of severe constraints that did not face other country groups in other periods: full exposure to pressures of global competition, depredation of the productive workforce, weak industrial sector etc. (Kessides, 2005).

The ability of African cities to cope economically, environmentally, and politically with such acute concentrations of people is subject to serious concerns. Many conjecture that disadvantages of African agglomerations such as social costs of a progressive overloading of housing and social services, of increased crime, pollution, and congestion outweigh their expected urban advantages in terms of agglomeration economies (Todaro, 1997).

Economics don't appear as the only drive of urban development in that region. In Behrens and Pholo Bala (2006), we have indeed shown how the synergy between scale economies and political factors may explain the apparition of urban agglomerations that would not have emerged otherwise. According to this theoretical setting cumulative causation arises thanks to the ability of political leaders to extract rents from hinterland to the capital city. In this framework the primate city appears merely as 'parasitic' in the Hoselitz (1955) sense since such transfers divert resources from productive use and therefore may impede long run economic growth.

However, relying on this rent seeking story may not be the only way to explain emergence of agglomerations in Black Africa. From the few papers attempting to explain spatial distribution in developing countries, Krugman and Elizondo (1996)' gives some clues by outlining the linkage between trade policies and urban development. They explain urban concentration in developing countries and especially in Mexico by the import-substitution policies which by closing local markets strengthen backward and forward linkages and thus favor agglomerations. So they predicted that once an economy is opened up urban concentration may shrink.

Actually import-substitution policies applied after political independence in many countries of Africa and Latin America were characterized by a strong urban bias flavor. With their focus on industrialization, technological sophistication, modern education and metropolitan growth, such strategies induced a significant spatial imbalance in economic and noneconomic opportunities between rural and urban areas and therefore contributed significantly to rural-urban migration (Todaro, 1997; Mabogunje, 1994). However, the failure of industrialization strategies in SSA has not been followed by a shrinking of the size of african agglomerations. Moreover, despite of this industrial collapse Africa urban growth rates go unabated. Therefore, Krugman and Elizondo argument does not provide a convincing explanation of Africa 's urban development.

One way to tackle satisfactorily that issue may be to analyze the impact of international trade in the spatial distribution of economic activities in a setting featuring an asymmetric location of regions. Most of NEG contributions addressing the impact of international trade in the distribution of firms in a domestic economy (Krugman and Elizondo, 1996; Monfort and Nicolini, 2000; Behrens *et al.*, 2007) imply a symmetric location of regions. In such frameworks there is no room for locational advantages or disadvantages. They would rather imply that all locations of SSA have the same accessibility to foreign countries. This is actually hardly plausible, a basic stylized fact of SSA urban geography being that most of the largest cities of Africa are located along the coast. The logic behind such a locational preference for coastal sites is that, because of the heavy import dependence of SSA economic strategies, port cities are the preferred location for industrial development (Mabogunje, 1994). This feature is not new, it holds since the beginning of colonization: at that time ports were vital for the outward shipment of raw materials back to the colonizing countries and the inward shipment of manufactured goods. By 1900 when the partition of the continent was effectively achieved, 25 (i.e. about 69%) of the 36 capitals of countries having a sea access were located in the coast (See Figure 7 in Appendix A). From that time on population redistribution toward these coastal cities did not cease. It rather increased as those cities retained and extended their dominance as the primary centers of economic activities (Kempe, 1996). Indeed, 15 of the 25 coastal colonial capitals in existence in 1900 still retain their status in 1991 (Figure 8 in Appendix B). Independence therefore has not induced dramatic changes in spatial distribution of economic agents. Even in the few cases where the capital were moved from the hub to an interior location, the hub remained the primate city. This is the case in Côte d'Ivoire, Nigeria, Cameroun, Tanzania where the capitals were respectively moved from Abidjan to Yamoussoukro, from Lagos to Abuja, from Douala to Yaounde and from Dar es Salaam to Dodoma. Therefore, as in colonial times most of the primate cities, 23 out of 33 (i.e. about 70%), have a coastal location.

The fact that the spatial structures of most African economies are strongly focused on a small number of port cities clearly points out to a hub effect which discards the symmetry assumption. So one of the explanations of the localization of firms and consumers in SSA may rely on gate effects. There is some literature on hub effects (Fujita and Mori, 1996;

Krugman, 1993). But only few recent NEG contributions have addressed convincingly hub effects issues, reducing further the gap between a reality where geography and locational advantages (the so-called 'First Nature') are part of the story of economic agents localization and most of NEG papers which abstracted from geographical features to focus on purely economic mechanisms (the so-called 'Second Nature').

Ago *et al.* (2006) for instance analyze the impacts of falling transport costs on the spatial distribution of economic activities and welfare for a network economy consisting of three regions located on a line. They showed that, conversely to a Krugman setting which implies concentration in the central region (the so-called hub), this may not be the case in a Ottaviano *et al.* (2002) (henceforth, OTT) model because price competition is so intense in the central region that it may reduce welfare. Our framework adopts a similar structure with three regions located on a line, but departs from the symmetry assumption implied by Ago *et al.* (2006)' setting with two similar 'peripheral regions' endowed with the same mass of skilled and unskilled workers, and transport costs that are equivalent between the hub and each one of the peripheral regions. To better capture the impact of international trade on the distribution of firms in the domestic economy, we make the sensible assumption that the two 'peripheral' regions of our setting namely the rest of the World and the Hinterland are heterogeneous. Moreover, we assume that transport costs between the hub and each other region differ: interregional trade frictions between the Hub and the hinterland are merely constituted by transport costs and are called as such. Conversely, trade between the hub and the rest of the World also includes in addition to transport costs other international trade impediments related to institutional factors like trade policy, customs duties and formalities, or adaptation to foreign legislation etc. We denote all those international trade barriers by trade costs.

Behrens *et al.* (2006) on the other hand study the impacts of international trade and domestic transport costs on the internal geography of a country by using a two-country four regions model in which one country has a region that exhibits a 'geographical advantage' in terms of better access to the other country's market. Their main results are that the space-economies of the trading partners are interdependent and that agglomeration in one country reduces the occurrence of agglomeration in the other. They further find that the landlocked region may be the location that attracts the larger share of firms especially when transport costs in the gated country are high. Like us they make a distinction between interregional trade barriers, 'transport costs', and international trade impediments, the 'trade costs'. Nevertheless, the major difference between our model and those two contributions is that we consider firms distribution in the rest of the world as exogenous while they consider repartition of firms in any region as endogenous. Based on this assumption, Behrens *et al.* (2006) find that distribution of firms in countries involved in trade are interdependent. We believe however that such result may not be sensible for SSA. Indeed, with a share of international trade converging to that region not exceeding 3%, it can not be expected to have a substantial influence on the location of foreign activities.[1]

Therefore, conversely to the latter contributions, our framework has the specificity to assume asymmetry between the Rest of the World and the Hinterland and the independence of foreign firms localization with respects to localization choices in the Domestic Economy and is likely to offer a more realistic explanation of spatial location of firms in SSA. Moreover, our setting may deal with the paradox of the increasing integration of SSA with foreign countries through international trade, and its low interregional integration because of its poor communication infrastructure, and subsequent high transport costs.[2]

The remainder of this paper is organized as follows. Section 2 presents the common structure of the two models presented in this paper. In Section 3, we develop the Footloose Entrepreneur Model and present simulation results. Section 4 then investigates the spatial equilibrium in the OTT model and presents the most significant analytical findings. We finally conclude in Section 5.

# 2 Structure of the economy

We consider an economy consisting in three locations, Regions $i \in \{0, 1, 2\}$, located equidistantly on a line. Region 0 depicts the rest of the world, while Regions 1 and 2 are domestic locations. Without loss of generality we assume that Region 1 is the capital and the hub of our domestic economy, while Region 2 represents its hinterland.

There are two factors of production: skilled and unskilled labor. Total labor endowments for skilled and unskilled labor are respectively $H$ and $L$. Masses of skilled and unskilled labor are respectively $H_F = H_0$ and $L_F = L_0$ in the rest of the World and $H_D$ and $L_D$ in

[1] According to OECD data (`http://www.oecd.org/dataoecd/53/47/39759637.pdf`), from 2000 to 2006, African exports has increased to reach the value of 290 billions dollars and African share of International trade has increased from 2.0% to 2.3%.

[2] A remarkably vivid description of communication infrastructure in SSA may be found in the article "The road to hell is unpaved" of the December 19, 2002, print edition of The Economist (available online at `http://www.economist.com/ PrinterFriendly.cfm?Story_ID=1487583`). Due to administrative hassle, 47 road-blocks and poor infrastructure, a 500 km trip by truck from Douala to Bertoua took the authors four days, with only two-thirds of the original load arriving at its destination. Therefore, high transaction costs add substantially to total shipping costs.

the domestic economy. Unskilled workers are immobile. To avoid giving to any domestic region an advantage in terms of its unskilled demand, we assume that all of them have the same share of domestic unskilled workers $L_i = \frac{1}{2}L_D$ for $i \in \{1, 2\}$. Skilled workers may move within the domestic economy while foreign skilled workers are immobile. So while the mass of skilled workers in foreign locations $H_F$ is exogenous because of factor immobility between the Domestic Economy and the rest of the World, the distribution of skilled between domestic locations is endogenous with $H_1$ and $H_2$ respectively the masses of skilled in the hub and the hinterland regions. Those assumptions are in line with empirical evidence: there is no evidence of any significant brain drain from Rest of the World to SSA, it is rather in the other direction than skilled migration is substantial.[3] Moreover, in SSA educated persons have a higher propensity to migrate than less qualified people (Byerlee, 1974).[4]

In each region there are two production sectors, manufacturing and agriculture. By using exclusively unskilled labor, the agricultural sector produces a homogeneous good. We assume this good as costlessly tradable across regions. Moreover, we normalize, without any loss of generality, the unit input coefficient in this sector to one. Then by perfect competition and costless trade unskilled wages $w^L$ are equalized across regions: $w_i^L = 1$ for $i \in \{0, 1, 2\}$. On the other hand the manufacturing sector requires both skilled and unskilled labor to produce horizontally differentiated varieties of manufactured good.

As previously mentioned trade is inhibited by frictional trade barriers that are different according to the origin and destination involved. More exactly transactions between the rest of the world and the hub and those between the hub and the hinterland imply different 'trade' costs.

We assume that there is a continuum of potential firms so that the impact of each firm on the market outcome is negligible. Since we assume that there is no economy of scope, each variety is produced by a single firm in only one region. Because varieties are symmetric, each firm's output is equalized in equilibrium. We further make the standard assumption that mobile workers are short-sighted and choose their locations as to maximize their well-being captured by their indirect utility. Supposing that market clearing conditions hold,

[3]Considering this brain drain, we could actually allow 'Domestic' skilled workers to move from the Domestic Economy to the Rest of the World, but since empirically the number of SSA skilled workers represents only a small share of Foreign skilled workers, this would complicate the calculations without providing in exchange any additional insight.

[4]Byerlee even stated that the dominance of school-leavers in the migration stream in SSA is stronger relative to Latin America and Asia where illiterate landless laborers and tenants make up a significant proportion of migrants.

the equilibrium distribution of firms in the Domestic Economy is given by the scalar $\lambda$ and mobile labor migration is regulated by the following Marshallian adjustment process:

$$\dot{\lambda} \equiv \frac{d\lambda}{dt} = \begin{cases} \Delta V(\lambda) & \text{if } 0 < \lambda < 1 \\ \min\{0, \Delta V(\lambda)\} & \text{if } \lambda = 1 \\ \max\{0, \Delta V(\lambda)\} & \text{if } \lambda = 0 \end{cases} \tag{1}$$

where $\Delta V$ depicts the indirect utility differential.

To check up the robustness of our results, we will analyze the impact of international trade on the domestic space-economy by using two different models, namely the so-called 'Footloose Entrepreneur Model' of Forslid and Ottaviano (2003) and the linear model of Ottaviano *et al.* (2002). Because of its relative analytical intractability, we will use the 'Footloose Entrepreneur Model' as a benchmark pointing to key results through simulations. For crucial analytical results we will rely mostly on the OTT version.

# 3 Footloose Entrepreneur Model

This model is based on Forslid and Ottaviano (2003) with CES utility function, iceberg transport costs.

## 3.1 Preferences

A representative consumer in Region $i \in \{0, 1, 2\}$ has Cobb-Douglas upper-tier preferences over agricultural and manufactured goods, with a CES sub-utility over a continuum of horizontally differentiated varieties. Therefore, he maximizes the following utility function:

$$A_i^{1-\mu} \left( \int_{\Omega_0} q_{ii}(\omega)^{\frac{\sigma-1}{\sigma}} d(\omega) + \int_{\Omega_1} q_{ji}(\omega)^{\frac{\sigma-1}{\sigma}} d(\omega) + \int_{\Omega_2} q_{ki}(\omega)^{\frac{\sigma-1}{\sigma}} d(\omega) \right)^{\frac{\mu\sigma}{\sigma-1}}$$

given the constraint:

$$p^A A_i + \left( \int_{\Omega_0} p_{ii} q_{ii}(\omega) d(\omega) + \int_{\Omega_1} p_{ji} q_{ji}(\omega) d(\omega) + \int_{\Omega_2} p_{ki} q_{ki}(\omega) d(\omega) \right) = y_i$$

where $A_i$ is the consumption of agricultural good; $q_{ji}(\omega)$ and $p_{ji}(\omega)$ represent the quantity and the price of variety $\omega$ consumed in country $i$ and produced in country $j$; $\Omega_i$ stands for the set of varieties produced in country $i$, with measure $n_i$; $y_i$ is the income of the representative consumer in region $i$.

By the homotheticity of preferences, we obtain the following aggregate demand for firm $\omega$ in region $i$ when it is located in region $j$:

$$D_{ji}(\omega) = \frac{p_{ji}(\omega)^{-\sigma}}{\mathbb{P}_i^{1-\sigma}} \mu Y_i \tag{2}$$

where $Y_i$ is the total income of agents in region $i \in \{0, 1, 2\}$ including skilled ($w_i$) and unskilled wages ($w_i^L$):

$$Y_i = w_i H_i + w_i^L L_i \tag{3}$$

and $\mathbb{P}_i$ is the CES price aggregate. Assuming that all varieties produced in each region are symmetric allows us to alleviate notation by dropping the variety index $\omega$. The price aggregate $\mathbb{P}_i$ then reduces to

$$\mathbb{P}_i = \left( n_i p_{ii}^{1-\sigma} + n_j p_{ji}^{1-\sigma} + n_k p_{ki}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}. \tag{4}$$

## 3.2 Technology and transportation

Frictional trade barriers are modeled as iceberg costs. As stated previously they are asymmetric: trade of one unit of differentiated good between the rest of the world to the hub region entails shipping of $\rho$ units of differentiated good, while it entails $\tau$ units of differentiated goods from the hub to the hinterland region.

In this model factor wages equalization only holds when the homogeneous good is produced in all the regions (Forslid and Ottaviano, 2003; Baldwin *et al.*, 2003). Such non-full-specialization condition is verified only if the agricultural good has an important weight in the utility ($\mu$ small) and if product variety is highly valued by consumers.[5]

Each firm of the manufacturing sector requires $F$ units of skilled labor as a fixed input requirement and $m$ units of unskilled labor per unit of output as a variable input requirement. Total production costs of producing a quantity $Q$ in region $i \in \{0, 1, 2\}$ are then given by

$$\mathrm{TC}_i(Q) = mQ + F w_i.$$

With such a fixed cost requirement, skilled labor market clearing then requires that the masses of firms in the regions are as follows:

$$n_0 = \frac{H_F}{F} \qquad n_1 = \frac{\lambda H_D}{F} \qquad n_2 = \frac{(1-\lambda) H_D}{F} \qquad N = n_0 + n_1 + n_2 \tag{5}$$

[5] Formally, in this three regions framework, if each region has an equal share of unskilled workers $L_i = \frac{1}{3} L$ for $i \in \{0, 1, 2\}$, the exact condition is $\mu < \sigma/(3\sigma - 2)$.

where $\lambda$ represents the share of the domestic unskilled labor endowment located in the hub region.

The profit of a representative firm in region $i$ is given by

$$\Pi_i = (p_{ii} - m)\, D_{ii} + (p_{ij} - m)\, D_{ij} + (p_{ik} - m)\, D_{ik} - F w_i,$$

where the demands are evaluated at (2). Taking into account the frictional trade barriers previously mentioned, profit-maximizing prices exhibit a constant mark-up over marginal cost:

$$\begin{aligned}
p_{00}^* &= p_{11}^* = p_{22}^* = \frac{\sigma m}{(\sigma - 1)} \\
p_{01}^* &= p_{10}^* = \frac{\sigma m \rho}{(\sigma - 1)} \\
p_{12}^* &= p_{21}^* = \frac{\sigma m \tau}{(\sigma - 1)} \\
p_{02}^* &= p_{20}^* = \frac{\sigma m \tau \rho}{(\sigma - 1)}
\end{aligned}$$

Replacing prices by those expressions into (4), and using the skilled labor market clearing conditions (5), we get the following price indices:

$$\mathbb{P}_0 = \frac{\sigma m}{(\sigma - 1)} \left(\frac{H_D}{F}\right)^{\frac{1}{1-\sigma}} \left[\frac{H_F}{H_D} + \lambda \rho^{1-\sigma} + (1-\lambda)\,(\tau\rho)^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{6}$$

$$\mathbb{P}_1 = \frac{\sigma m}{(\sigma - 1)} \left(\frac{H_D}{F}\right)^{\frac{1}{1-\sigma}} \left[\frac{H_F}{H_D}\rho^{1-\sigma} + \lambda + (1-\lambda)\,\tau^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{7}$$

$$\mathbb{P}_2 = \frac{\sigma m}{(\sigma - 1)} \left(\frac{H_D}{F}\right)^{\frac{1}{1-\sigma}} \left[\frac{H_F}{H_D}\,(\tau\rho)^{1-\sigma} + \lambda \tau^{1-\sigma} + (1-\lambda)\right]^{\frac{1}{1-\sigma}} \tag{8}$$

In this paper we want to study the distribution of skilled workers (i.e. of firms) between the hub and the hinterland regions. To do so we need to derive equilibrium skilled wage expressions for the aforementioned regions. Because the three locations have different accessibility, product market clearing conditions yield asymmetric expressions for total quantities produced in Regions 0, 1 and 2. So we get:

$$\begin{aligned}
X_0 &= D_{00} + \rho D_{01} + \tau\rho D_{02} \\
&= \frac{\mu(\sigma-1)}{m\sigma}\left(\frac{Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{\phi_\rho Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{\phi_\tau\phi_\rho Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (9) \\
X_1 &= D_{11} + \rho D_{10} + \tau D_{12} \\
&= \frac{\mu(\sigma-1)}{m\sigma}\left(\frac{\phi_\rho Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{\phi_\tau Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (10) \\
X_2 &= D_{22} + \tau D_{21} + \tau\rho D_{20} \\
&= \frac{\mu(\sigma-1)}{m\sigma}\left(\frac{\phi_\tau\phi_\rho Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{\phi_\tau Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (11)
\end{aligned}$$

where $\phi_\tau = \tau^{1-\sigma}$ and $\phi_\rho = \rho^{1-\sigma}$ stand for freeness of respectively interregional and international trade.

As firms price above marginal cost, there exist pure operating profits which are competed away by firms' bidding for skilled labor. Therefore, in equilibrium the skilled wages absorb all operating profits:

$$\begin{aligned}
w_0 &= \frac{\mu}{\sigma F}\left(\frac{Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{\phi_\rho Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{\phi_\tau\phi_\rho Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (12) \\
w_1 &= \frac{\mu}{\sigma F}\left(\frac{\phi_\rho Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{\phi_\tau Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (13) \\
w_2 &= \frac{\mu}{\sigma F}\left(\frac{\phi_\tau\phi_\rho Y_0}{n_0 + n_1\phi_\rho + n_2\phi_\tau\phi_\rho} + \frac{\phi_\tau Y_1}{n_0\phi_\rho + n_1 + n_2\phi_\tau} + \frac{Y_2}{n_0\phi_\tau\phi_\rho + n_1\phi_\tau + n_2}\right) \qquad (14)
\end{aligned}$$

Using (5), (12), (13) and (14) can take the final expressions:

$$\begin{aligned}
w_0 &= \frac{\mu}{\sigma H_D}\left(\frac{Y_0}{\lambda_{FD} + \lambda\phi_\rho + (1-\lambda)\phi_\tau\phi_\rho} + \frac{\phi_\rho Y_1}{\lambda_{FD}\phi_\rho + \lambda + (1-\lambda)\phi_\tau} + \frac{\phi_\tau\phi_\rho Y_2}{\lambda_{FD}\phi_\tau\phi_\rho + \lambda\phi_\tau + (1-\lambda)}\right) \qquad (15) \\
w_1 &= \frac{\mu}{\sigma H_D}\left(\frac{\phi_\rho Y_0}{\lambda_{FD} + \lambda\phi_\rho + (1-\lambda)\phi_\tau\phi_\rho} + \frac{Y_1}{\lambda_{FD}\phi_\rho + \lambda + (1-\lambda)\phi_\tau} + \frac{\phi_\tau Y_2}{\lambda_{FD}\phi_\tau\phi_\rho + \lambda\phi_\tau + (1-\lambda)}\right) \qquad (16) \\
w_2 &= \frac{\mu}{\sigma H_D}\left(\frac{\phi_\tau\phi_\rho Y_0}{\lambda_{FD} + \lambda\phi_\rho + (1-\lambda)\phi_\tau\phi_\rho} + \frac{\phi_\tau Y_1}{\lambda_{FD}\phi_\rho + \lambda + (1-\lambda)\phi_\tau} + \frac{Y_2}{\lambda_{FD}\phi_\tau\phi_\rho + \lambda\phi_\tau + (1-\lambda)}\right) \qquad (17)
\end{aligned}$$

with $\lambda_{FD} = \frac{H_F}{H_D}$.

We can now analyze the market outcome for any *given* spatial distribution of domestic skilled workers across domestic locations. Considering that net aggregate incomes are given by expression (3), the market outcome yields unique solution in $w_0$, $w_1$ and $w_2$ .[6] Having expressions of this solution we can now discuss the spatial equilibrium. As indicated earlier mobile labor migration in the Domestic Economy is regulated by the aforementioned Marshallian adjustment process described by (1). It is a myopic adjustment process whose

[6]Expressions of this solution are quite long, so we put them in the Appendix C

driving force is skilled workers' current utility differential between the hub and the hinterland. This utility differential has the following expression:

$$\Delta V(\lambda) = \mu^{\mu}(1-\mu)^{1-\mu}\left(\frac{w_1}{\mathbb{P}_1^{\mu}} - \frac{w_2}{\mathbb{P}_2^{\mu}}\right).$$

## 3.3 Benchmark case: a closed domestic economy

When the Domestic economy is closed, that is when $\rho \to \infty$ (or $\phi_\rho \to 0$) , we are in the benchmark case of Forslid and Ottaviano (2003). Indeed, $\Delta V$ reduces to

$$\begin{aligned}\frac{\Delta V(\lambda)}{\Phi} &= \frac{2\lambda\sigma\phi_\tau + (1-\lambda)\left[\sigma\left(\phi_\tau^2+1\right) - \mu\left(1-\phi_\tau^2\right)\right]}{\left[(1-\lambda)\phi_\tau + \lambda\right]^{\frac{\mu}{1-\sigma}}} \\ &\quad - \frac{2(1-\lambda)\sigma\phi_\tau + \lambda\left[(\mu+\sigma)\phi_\tau^2 + (\sigma-\mu)\right]}{\left[\lambda\phi_\tau + (1-\lambda)\right]^{\frac{\mu}{1-\sigma}}}. \end{aligned} \tag{18}$$

where $\Phi$ is a strictly positive bundle of parameters given by the following expression

$$\Phi \equiv \frac{L(1-\mu)^{1-\mu}\mu^{\mu+1}}{\eta}\left[\frac{m\left(\frac{H}{F}\right)^{\frac{1}{1-\sigma}}\sigma}{(\sigma-1)}\right]^{-\mu}$$

with

$$\eta \equiv \left((1-\lambda)^2 + \lambda^2\right)\,\sigma\,\phi_\tau + \left(\sigma - \mu + (\mu+\sigma)\,{\phi_\tau}^2\right)(1-\lambda)\,\lambda$$

It is shown in Forslid and Ottaviano (2003) that full agglomeration may be sustained as an equilibrium if and only if

$$\frac{\Delta V^*(\lambda)}{\Phi}\Big|_{\lambda=1} = -\frac{\Delta V^*(\lambda)}{\Phi}\Big|_{\lambda=0} = 2\sigma\phi_\tau - \frac{(\mu+\sigma)\phi_\tau^2 + (\sigma-\mu)}{\phi_\tau^{\frac{\mu}{1-\sigma}}} > 0,$$

Therefore, the sustain point $\phi_\tau^s$ may be defined as the value of $\phi_\tau$ that equates the above expression to zero and full agglomeration can be sustained for all $\phi_\tau \geq \phi_\tau^s$. Moreover, there are at most three interior equilibria in the closed Domestic economy case (Robert-Nicoud, 2005), of which the symmetric one ($\lambda^* = 1/2$) always exists. The stability of the equilibrium $\lambda^* = 1/2$ depends on the sign of the derivative of the indirect utility differential, whereas the other two interior equilibria are always unstable. Computing $\partial(\Delta V^*)/\partial\lambda$ and evaluating it at $\lambda = 1/2$, the break-point is such that

$$\phi_\tau^b \equiv \frac{\sigma-\mu}{\sigma+\mu}\frac{\mu-\sigma+1}{1-\mu-\sigma}.$$

Hence, $\lambda^* = 1/2$ is a stable spatial equilibrium for all $\phi_\tau \leq \phi_\tau^b$. Note, finally, that both types of equilibria occur for values $\phi_\tau^s \leq \phi_\tau \leq \phi_\tau^b$, in which case both full agglomeration and full dispersion are stable spatial equilibria.

## 3.4 Case of an open domestic economy

The general case of an open economy yields a much longer and more complicated expression of the indirect utility differential. As a consequence we can not characterize spatial equilibrium analytically.[7] We therefore rely on simulations to provide sensible results.[8] Figure 1 shows the real wage differential in case of a close economy and for a high value of interregional transport cost. It indicates that the symmetric equilibrium is stable since the real wage differential is zero for $\lambda = 0.5$ and it has a negative slope at that point.

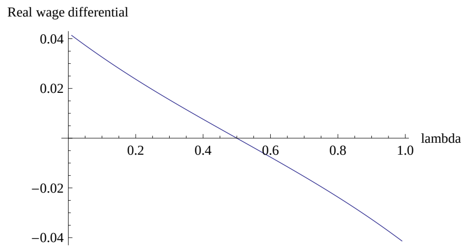


Figure 1: Real wage differential in case of high transport costs ($\tau = 2.1$) and a closed economy ($\phi_\rho = 0$)

Allowing for international trade implies a different story. Figure 2 displays a graph of the real wage differential as a function of the spatial distribution of firms in the Domestic economy in case of the absence of any international trade friction. It shows that there is not any interior equilibrium; the only equilibrium being agglomeration in the Hub. International trade induces an asymmetry between the two regions of the market, since the latter have different accessibility to the foreign market and domestic firms prefer to locate in the region having the higher market potential.

In the case of low ($\rho = 1.2$) or even relatively high international trade costs ($\rho = 3$), the same story holds: no interior equilibrium and agglomeration in the Hub (Figure 3).

[7] Ago *et al.* (2006) were able to obtain meaningful analytical results in a three regions model à la Krugman featuring symmetry. However, in a asymmetric framework things are much more involved

[8] To perform those simulations we gave the following values to model parameters: $\mu = 0.4$, $\sigma = 2.7$, $H = 10$, $H_D = 1$, $L_D = 0.852$, $H_F = 9$, $L_F = 7.668$, $F = 1$, $m = 0.4$. Values of $H_D$ and $L_D$ have been set conforming to standard normalization in the FE model (Baldwin *et al.*, 2003). We assume that the Domestic Economy and the Rest of the World have the same ratio of unskilled to skilled workers. The values of $H_F = 9$ and $H = 10$ come from the fact that conforming to World Bank data on labor force, the mass of workers in the Rest of the World is about tenfold that of SSA (the total labor force respectively in World and in SSA were in 2006 $3,077.9$ and 322.8 billions. Data are available online on the World Bank Website http://www.worldbank.org)

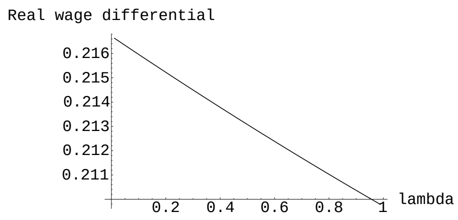


Figure 2: Real wage differential in case of high transport costs ($\tau = 2.1$) and an open economy ($\phi_\rho = 1$)

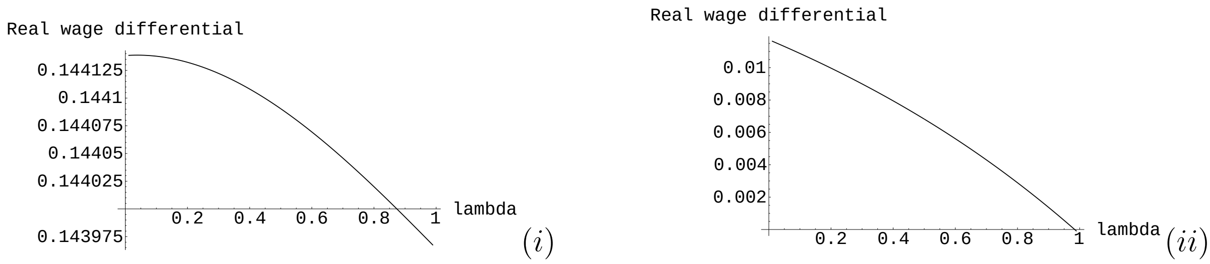


Figure 3: Real wage differential in case of high transport costs ($\tau = 2.1$) and with respectively low trade costs ($\rho = 1.2$, panel $(i)$) and high trade costs ($\rho = 3$, panel $(ii)$)

It is only for much higher international trade costs that a stable interior spatial equilibrium appears. But this spatial equilibrium may not be the symmetric one. Indeed, with $\rho = 3.5$ the spatial equilibrium implies a share of skilled workers slightly greater than one half in the hub. But for higher trade costs, for instance $\rho = 4$ (respectively $\rho = 5$) the spatial equilibrium implies a value of $\lambda$ equal to 1/3 (respectively 26%) of skilled workers in the gated region (Figure 4). Therefore, in case of an open economy, very high trade costs induce spatial equilibrium with partial agglomeration in the hinterland. The rationale of this localisation of most firms in the hinterland is that, because of higher trade costs, the market potentiel of firms in the hub is reduced. Therefore, the gated region is less profitable and interregional transport costs provide hinterland firms a good protection against foreign firms competition.

The role of high interregional transports as a shield against foreign competition is further emphasized in simulations with very high transport costs ($\tau = 5$). In this case we find as before that, for a closed Domestic economy, the symmetric distribution of firms is as previously the only stable equilibrium and that in case of the lack of any international trade friction there is no interior equilibrium. But with higher trade costs partial agglomeration in the hinterland occurs for lower values of international trade frictions than it was the case before. Figure 5 shows that for $\rho = 2.5$, a stable partial equilibrium occurring with

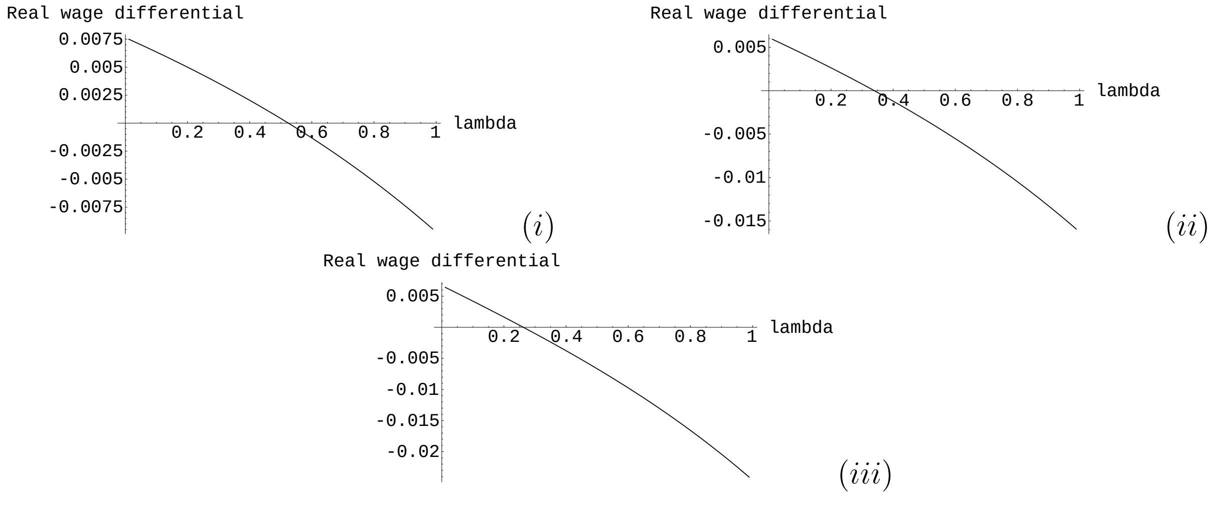


Figure 4: Real wage differential in case of high transport costs ($\tau = 2.1$) and with very high trade costs ($\rho = 3.5$ for panel ($i$), $\rho = 4$ for panel ($ii$), and $\rho = 5$ for panel ($iii$))

a value of $\lambda$ slightly below 20%. So the higher are transport costs, the more they provide protection against foreign firms competition.

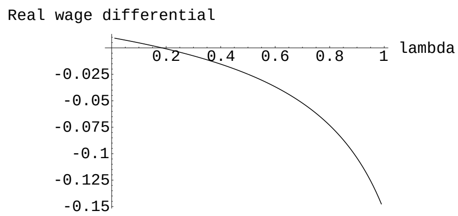


Figure 5: Real wage differential for very high transport costs ($\tau = 5$) and high trade costs ($\rho = 2.5$)

Those numerical examples provide interesting results. They show up that openness with low international trade costs provide good impulse for hub agglomeration. However, once those trade costs exceed some threshold, the hinterland became the favorite location for most of firms and the higher are transport costs, the lower are those thresholds. However, simulations can not provide a complete gallery of results.[9] So now we consider results

[9] One may for instance want to check what would be the spatial structure of a much smaller domestic economy. Simulations with mass of foreign skilled workers ninety nine times greater than mass of domestic skilled workers imply systematically full agglomeration in the hub. The intuition behind such a result is that more firms in the rest of the World intensifies competition in the same way as lower trade costs. When the rest of the World is large relatively to the domestic economy, locating in the landlocked region does not protect firms anymore, so agglomeration takes place

provided by the OTT Model which allows for more analytical tractability.

# 4 OTT Model

Some underlying assumptions of the Footloose Entrepreneur Model implies, as it is the case for the classical Core Periphery Model, several shortcomings. Firstly it entails equilibrium prices that are independent of the spatial distribution of firms and consumers, a result that conflicts with research in spatial pricing theory that shows that demand elasticity varies with distance while prices change with the level of demand and the intensity of competition. Secondly the iceberg assumption implies the unrealistic result that any increase in the price of the transported good is accompanied by a proportional increase in its trade cost.

Referring to Ottaviano *et al.* (2002), we use another modeling strategy that is short of these drawbacks. It is based on quadratic utility and on additive transport costs that are not incurred in the good itself. This allows us to derive analytically the results previously obtained.

## 4.1 Preferences

We assume that each worker is endowed with one unit of labor and $\bar{q}_0 > 0$ units of the numéraire and the initial endowment $\bar{q}_0$ is large enough for her consumption of the numéraire to be strictly positive at the market outcome.

Consumers have identical preferences described by a quasi-linear utility with a quadratic subutility. Therefore, a typical resident of region $i$ faces the following consumption problem:

$$\max_{q_i(\omega),\omega\in[0,N]} \quad \alpha\int_0^N q_i(\omega)\,d(\omega) - \frac{\beta-\gamma}{2}\int_0^N q_i(\omega)^2 d(\omega) - \frac{\gamma}{2}\left[\int_0^N q_i(\omega)d(\omega)\right]^2 + q_0$$

$$\text{s.t.} \quad \int_0^N p_i(\omega)\,q_i(\omega)\,d(\omega) + q_0 = y_i + \bar{q}_0$$

where $\alpha > 0$ and $\beta > \gamma > 0$ are parameters, $p_i(\omega)$, $q_i(\omega)$ are respectively consumer price and quantity of variety $\omega$ in region $i$ and $y_i$ is the individual's labor income in region $i$.

in the gate. This gives some ground to the empirical result that smaller countries have larger primate cities. We thank Kristian Behrens for this intuition. Adjusting for labor productivity may also be relevant as labor productivity in Sub-Saharan Africa is the twelfth of that of developed nations (`http://www.ilo.org/public/english/employment/strat/kilm/download/kilm18.pdf`). Such an adjustement would increase the relative size of the rest of the World and thus would magnify hub locational advantages.

Assuming that all varieties produced in each region are symmetric, we may alleviate notation by dropping the variety index $\omega$. Considering that $q_{ij}$ denotes the output of a firm located in region $i$ demanded by a consumer in region $j$, it is readily verified that the individual demand functions are given by:

$$q_{ij} = a - (b + cN)\, p_{ij} + cP_j \tag{19}$$

where

$$a = \frac{\alpha}{\beta + (N-1)\,\gamma}, \quad b = \frac{1}{\beta + (N-1)\,\gamma}, \quad c = \frac{\gamma}{(\beta - \gamma)\,(\beta + (N-1)\,\gamma)}$$

$p_{ij}$ is the price a firm located in region $i$ charges to consumers in region $j$ and with

$$P_j = \sum_{i\ \in\ \{0,1,2\}} n_{ij} p_{ij}. \tag{20}$$

the price index of varieties in region $j$.

## 4.2 Technology

As in the Footloose Entrepreneur Model each firm of the manufacturing sector requires a constant amount of skilled labor, denoted hereafter by $\phi$, as a fixed input requirement and $m$ units of unskilled labor per unit of output as a variable input requirement. Without loss of generality, we set $m = 0$ in what follows. As demand functions are linear, this amounts to rescaling firms' demand intercepts (Ottaviano *et al.*, 2002). Given the technology in the modern sector, skilled labor market clearing requires the following masses in each region $i = 0, 1, 2$:

$$n_0 = n_F = \frac{H_F}{\phi}, \quad n_1 = \lambda \frac{H_D}{\phi}, \quad n_2 = (1-\lambda)\,\frac{H_D}{\phi}, \quad n_D = n_1 + n_2, \quad N = n_D + n_F \tag{21}$$

Making the standard assumptions that product markets are segmented, that labor markets are local and that firms bear all trade and transportation costs, firms in regions 0, 1 and 2 maximize profit given respectively by:

$$\begin{aligned}
\pi_0 &= p_{00}q_{00}\left(L_F+H_F\right)+\left(p_{01}-\tau\right)q_{01}\left(\frac{L_D}{2}+\lambda H_D\right) \\
&+ \left(p_{02}-\left(t+\tau\right)\right)q_{02}\left(\frac{L_D}{2}+\left(1-\lambda\right)H_D\right)-\phi w_0
\end{aligned} \tag{22}$$

$$\begin{aligned}
\pi_1 &= \left(p_{10}-\tau\right)q_{10}\left(L_F+H_F\right)+p_{11}q_{11}\left(\frac{L_D}{2}+\lambda H_D\right) \\
&+ \left(p_{12}-t\right)q_{12}\left(\frac{L_D}{2}+\left(1-\lambda\right)H_D\right)-\phi w_1
\end{aligned} \tag{23}$$

$$\begin{aligned}
\pi_2 &= \left(p_{20}-\left(\tau+t\right)\right)q_{20}\left(L_F+H_F\right)+\left(p_{21}-t\right)q_{21}\left(\frac{L_D}{2}+\lambda H_D\right) \\
&+ p_{22}q_{22}\left(\frac{L_D}{2}+\left(1-\lambda\right)H_D\right)-\phi w_2
\end{aligned} \tag{24}$$

Given those profits functions, profit-maximizing prices are as follows:

1. Intraregional prices

$$p_{ii}=\frac{a+cP_i}{2\left(b+cN\right)} \tag{25}$$

2. Interregional prices

$$p_{ij}=p_{jj}+\frac{t}{2} \tag{26}$$

   with $i,j\neq 0$

3. International prices

$$p_{ij}=p_{jj}+\frac{\tau_{ij}}{2} \tag{27}$$

   with $i$ or $j=0$, $i\neq j$ and

$$\begin{aligned}
\tau_{01} &= \tau_{10}=\frac{\tau}{2} \\
\tau_{02} &= \tau_{20}=\frac{t+\tau}{2}
\end{aligned}$$

We may notice that the price a firm sets in a region depends on the price index $P_i$ of this region, which depends itself on the prices set by all other firms. Since there is a continuum of firms, each firm is negligible and considers aggregate market conditions as given when setting its optimal price. But these aggregate market conditions must be consistent with firms' optimal pricing decisions. Hence, the (Nash) equilibrium price indices must satisfy the following equilibrium conditions:

$$P_0 = n_0p_{00}+n_1p_{10}+n_2p_{20} \tag{28}$$

$$P_1 = n_0p_{01}+n_1p_{11}+n_2p_{21} \tag{29}$$

$$P_2 = n_0p_{02}+n_1p_{12}+n_2p_{22} \tag{30}$$

The equilibrium price indices can be found by solving (28) – (30) using expressions (25) – (27). This yields:

$$P_0 = \frac{aN + (b + cN)\left((n_1 + n_2)\tau + n_2 t\right)}{2b + cN} \tag{31}$$

$$P_1 = \frac{aN + (b + cN)\left(n_0\tau + n_2 t\right)}{2b + cN} \tag{32}$$

$$P_2 = \frac{aN + (b + cN)\left(n_0\tau + (n_0 + n_1)\, t\right)}{2b + cN} \tag{33}$$

Substituting (31) – (33) into (25) gives the intraregional prices:

$$p_{00} = \frac{2a + c\left(n_D\tau + (1-\lambda)\, n_D t\right)}{2\,(2b + cN)} \tag{34}$$

$$p_{11} = \frac{2a + c\left(n_F\tau + (1-\lambda)\, n_D t\right)}{2\,(2b + cN)} \tag{35}$$

$$p_{22} = \frac{2a + c\left(n_F\tau + (\lambda n_D + n_F)\, t\right)}{2\,(2b + cN)} \tag{36}$$

Up to now we have implicitly assumed that trade and transport costs are sufficiently low for interregional and international trade to be bilateral, regardless of firm distributions. We precise now the conditions on $t$ and $\tau$ for trade to occur between any two regions at these equilibrium prices.

For interregional transport costs between Region 1 and Region 2, the following conditions

$$t \leq t_{12}^{trade} = \frac{2a\phi + c\tau H_F}{2b\phi + c\,(1-\lambda)\, H_D} \tag{37}$$

$$t \leq t_{21}^{trade} = \frac{2a\phi + c\tau H_F}{2b\phi + c\,(H_F + \lambda H_D)} \tag{38}$$

must hold for trade to occur respectively between Region 1 and Region 2 and between Region 2 and Region 1.

Evaluating (38) for $\lambda = 1$ yields the most stringent conditions for trade threshold concerning flows from region 1 to region 2 that hold for any spatial repartition of firms in the Domestic economy:

$$t_{21}^{trade} \rightarrow \frac{2a\phi + c\tau H_F}{2b\phi + c\,(H_F + H_D)}. \tag{39}$$

Those expressions outline clearly that trade between the two regions of the domestic economy is asymmetric. Indeed, requirements for trade between Region 2 and Region 1 are more stringent than between Region 1 and Region 2 reflecting the locational advantage of the hub and its status as the favored domestic region for trade. However, for both directions trade thresholds decrease with the value of trade costs. This implies that lower international trade costs may lead to a break down of internal trade when the regional markets of a country are poorly integrated, especially when one of the two regions has a good access to the international marketplace, an intuitive result already put forward by Behrens *et al.* (2006). This captures the fact that consumers tend to prefer cheaper imports to more expensive nationally produced ones.

Considering international trade costs between Region 0 and Region 1, the following conditions

$$\tau \leq \tau_{01}^{trade} = \frac{2a\phi + c(1-\lambda) H_D t}{2b\phi + cH_F} \tag{40}$$

$$\tau \leq \tau_{10}^{trade} = \frac{2a\phi + c(1-\lambda) H_D t}{2b\phi + c(H_F + \lambda H_D)} \tag{41}$$

apply. Once more those conditions point out trade asymmetry. For values of $\lambda > 0$, fulfilling conditions for existence of international trade is more involved from region 1 to region 0 than the other way round. It is therefore easier for the Rest of the World to export.

Nevertheless, we can see from (40) and (41) that for both directions the feasibility of international trade improves when interregional transport costs are high, and when concentration of firms in the hub is weak. As Behrens *et al.* (2007) point out this is because lower transport costs and firms' agglomerations exacerbate price competition in local markets, thus making penetration by outside firms more difficult.

Finally for trade to occur between regions 0 and 2, the following conditions have to be fulfilled

$$\tau \leq \tau_{02}^{trade} = \frac{2a\phi - (2b\phi + cH_F + c(1-\lambda) H_D) t}{2b\phi + cH_D} \tag{42}$$

$$\tau \leq \tau_{20}^{trade} = \frac{2a\phi - (2b\phi + cH_F + c\lambda H_D) t}{2b\phi + cH_F} \tag{43}$$

We can deduce from (42) and (43) that the higher are transport costs, the less feasible is trade between regions 0 and 2. Thus, costly interregional trade induces the closeness of the Hinterland with respect to International Trade.

It is easy to verify that the equilibrium gross profits earned by a firm established in region 1 on each separated market are as follows:

$$\pi_{11} = (b + cN) \left( \frac{L_D}{2} + \lambda H_D \right) p_{11}^2 \tag{44}$$

$$\pi_{10} = (b + cN) (L_F + H_F) (p_{10} - \tau)^2 \tag{45}$$

$$\pi_{12} = (b + cN) \left( \frac{L_D}{2} + (1-\lambda) H_D \right) (p_{12} - t)^2 \tag{46}$$

Because of the specifity of our set up, profit earned by hinterland firms in the rest of World is asymmetric with respect to hub firms. This is readily shown in the following expressions:

$$
\begin{aligned}
\pi_{22} &= (b+cN)\left(\frac{L_D}{2}+(1-\lambda)H_D\right)p_{22}^2 && (47)\\
\pi_{20} &= (b+cN)(L_F+H_F)(p_{20}-(t+\tau))^2 && (48)\\
\pi_{21} &= (b+cN)\left(\frac{L_D}{2}+\lambda H_D\right)(p_{21}-t)^2 && (49)
\end{aligned}
$$

Concerning local labor markets, the equilibrium wages of the skilled are determined by the standard bidding process in which firms compete for workers by proposing higher wages until no firm can profitably enter or exit the market. Consequently all operating profits are absorbed by the wage bill. Therefore, in equilibrium the skilled wage rate in region $i$ of the Domestic Economy satisfies the condition $\pi_i(w_i)=0$ which yields the following expressions for skilled wages in the Domestic economy:

$$
\begin{aligned}
w_1(\lambda) &= \left(\frac{(b\phi+cL)\phi}{4(2b\phi+cL)^2}\right)\Bigg[\left(\frac{L_D}{2}+\lambda H_D\right)(2a\phi+c((1-\lambda)L_Dt+L_F\tau))^2\\
&\quad+\left(\frac{L_D}{2}+(1-\lambda)H_D\right)(2a\phi+c((\lambda L_D+L_F)t+L_F\tau)-(2b\phi+c)t)^2\\
&\quad+(L_F+H_F)(2a\phi+c((1-\lambda)L_Dt+L_D\tau)-(2b\phi+c)\tau)^2\Bigg], && (50)\\
w_2(\lambda) &= \left(\frac{(b\phi+cL)\phi}{4(2b\phi+cL)^2}\right)\Bigg[\left(\frac{L_D}{2}+\lambda H_D\right)(2a\phi+c((1-\lambda)L_Dt+L_F\tau)-(2b\phi+c)t)^2\\
&\quad+\left(\frac{L_D}{2}+(1-\lambda)H_D\right)(2a\phi+c((\lambda L_D+L_F)t+L_F\tau))^2\\
&\quad+(L_F+H_F)(2a\phi+c((1-\lambda)L_Dt+L_D\tau)-(2b\phi+c)(t+\tau))^2\Bigg] && (51)
\end{aligned}
$$

The individual consumer surplus in region 1 associated with the equilibrium prices $p_{11}$, $p_{21}$, and $p_{F1}$ is given by:

$$
\begin{aligned}
S_1(\lambda) &= \frac{a^2H}{2b\phi}-\frac{aH_D}{\phi}\left[\lambda p_{11}+(1-\lambda)p_{21}+\frac{H_F}{H_D}p_{F1}\right]\\
&\quad+\frac{(b+cN)H_D}{2\phi^2}\left[\lambda p_{11}^2+(1-\lambda)p_{21}^2+\frac{H_F}{H_D}p_{F1}^2\right] && (52)\\
&\quad-\frac{cH_D^2}{2\phi^2}\left[\lambda p_{11}^2+(1-\lambda)p_{21}^2+\frac{H_F}{H_D}p_{F1}^2\right]^2,
\end{aligned}
$$

a symmetric expression holds for region 2. Mobile skilled workers living in the Domestic Economy move to the region offering the highest indirect utility. The indirect utility of a skilled worker living in region $i\in\{1,2\}$ is given by:

$$V_i(\lambda)=S_i(\lambda)+w_i(\lambda)+\bar{q}_0$$

## 4.3 Benchmark case: a domestic economy without the Rest of the World

In case of the insignificance of the Rest of the World, $L_F \to 0$ and $H_F \to 0$, our set-up reduces to the one of Ottaviano *et al.* (2002). Indeed, after straightforward calculations the following indirect utility differential is obtained:

$$\begin{aligned} \Delta V(\lambda) &\equiv V_1(\lambda) - V_2(\lambda) = S_1(\lambda) - S_2(\lambda) + w_1(\lambda) - w_2(\lambda) \\ &= Ct(t^* - t)\left(\lambda - \frac{1}{2}\right) \end{aligned} \tag{53}$$

where

$$C = \left[2b\phi(3b\phi + 3cH + cL) + c^2 H(L+H)\right] \frac{H(b\phi + cH)}{2\phi^2 (2b\phi + cH)^2} > 0$$

and

$$t^* = \frac{4a\phi(3b\phi + 2cH)}{2b\phi(3b\phi + 3cH + cL) + c^2 H(L+H)}$$

It is clear for (53) that $\lambda = 1/2$ is always an equilibrium. As $C > 0$, for $\lambda \neq 1/2$, the indirect utility differential has always the same sign as $(\lambda - 1/2)$ whenever $t < t^*$; otherwise it has the opposite sign. Thus, when $t < t^*$, the symmetric equilibrium is unstable and workers agglomerate in region 1 (2) provided that the initial fraction of skilled workers residing in this region is greater than 1/2. This yields the standard result obtained by Krugman (1991) that agglomeration arises when transport costs are low enough.

## 4.4 Spatial equilibrium analysis in the general case

Assuming that $L_F \neq 0$ and / or $H_F \neq 0$, after cumbersome but straightforward calculations the utility differential can be written as follows

$$\begin{aligned} \Delta V(\lambda) &\equiv V_1(\lambda) - V_2(\lambda) = S_1(\lambda) - S_2(\lambda) + w_1(\lambda) - w_2(\lambda) \\ &= \frac{t}{8\phi^2 (cH + 2b\phi)^2} \left[2\left(\lambda - \frac{1}{2}\right)(\eta_1 + \eta_2 \tau - \eta_3 t) + (\eta_4 - \eta_5 \tau - \eta_6 t)\right] \end{aligned} \tag{54}$$

where

$$
\begin{aligned}
\eta_1 &= 16a\phi H_D(b\phi + cH)(3b\phi + 2cH) > 0 && (55)\\
\eta_2 &= 4cH_D H_F(b\phi + cH)(4b\phi + 3cH) > 0 && (56)\\
\eta_3 &= 4H_D(b\phi + cH)\left(2bc\phi(L + 3H) + c^2H(L + H) + 6b^2\phi^2\right) > 0 && (57)\\
\eta_4 &= 8a\phi(b\phi + cH)\left(L_F(2b\phi + cH) + H_F(3b\phi + 2cH)\right) > 0 && (58)\\
\eta_5 &= 2(b\phi + cH)\left(2L_F(2b\phi + cH)(2b\phi + cH_F) + H_F\left(cH_F(4b\phi + cH)\right.\right. && \\
&\quad \left.\left. +(2b\phi + cH)(6b\phi + cH)\right)\right) > 0 && (59)\\
\eta_6 &= 2(b\phi + cH)\left(H_F\left(2bc\phi(L + 3H) + c^2H(L + H) + 6b^2\phi^2\right)\right. && (60)\\
&\quad \left. +2b\phi L_F(2b\phi + cH)\right) > 0 && (61)
\end{aligned}
$$

where $\eta_1$, $\eta_2$, $\eta_3$, $\eta_4$, $\eta_5$ and $\eta_6$ are positive bundles of parameters independent of the distribution of domestic firms.

Since the indirect utility differential includes an additional term independent of $(\lambda - 1/2)$, the conditions for the prevalence of the symmetric equilibrium in the domestic economy are much more restrictive in this framework than in the benchmark OTT model.[10] Thus, in this set-up dispersion is almost never an equilibrium.

The stringency of the conditions required to allow dispersion to be an equilibrium outlines the peculiarity of our set-up. With one region benefiting of a locational advantage, the framework is asymmetric and dispersion is no longer the 'natural' equilibrium it was in the Ottaviano *et al.* (2002) framework. Therefore, our set-up is characterized by a 'bias' towards (at least partial) agglomeration in either Domestic region.

The analysis of the impact of transport and trade costs on the spatial distribution of the domestic economy may be developed through four subcases as shown in figure (6).[11] We will focus mostly on the analysis of the two subcases corresponding to Regions I and II in figure (6) since they provide the most interesting and clear-cut analytical results. The first one implies that the following conditions hold simultaneously.

$$(\eta_1 + \eta_2\tau - \eta_3 t) \geq 0 \tag{62}$$

$$(\eta_4 - \eta_5\tau - \eta_6 t) \geq 0 \tag{63}$$

[10] The explicit conditions for the existence and the stability of a symmetric equilibrium are the following: $(\eta_1 + \eta_2\tau - \eta_3 t) < 0$ and $(\eta_4 - \eta_5\tau - \eta_6 t) = 0$. It is clear that they are hardly fulfilled simultaneously.

[11] As $\frac{\eta_1}{\eta_3} < \frac{\eta_4}{\eta_6}$ the two lines in figure (6) cross. Therefore, they divide the first quadrant in four regions corresponding to our four subcases.

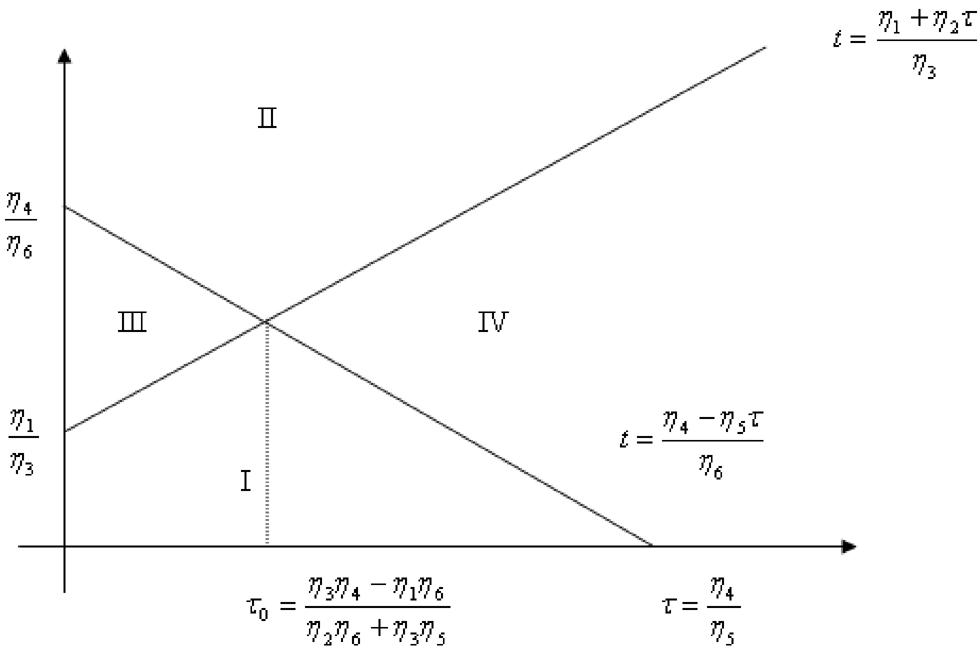


Figure 6: Trade and transport costs

Depending on the level of trade costs, we may express those conditions in terms on different transport thresholds. When

$$\tau < \tau_0 = \frac{\eta_3\eta_4 - \eta_1\eta_6}{\eta_2\eta_6 + \eta_3\eta_5}, \tag{64}$$

(62) is the more stringent condition.[12] It implies that :

$$t < \frac{\eta_1 + \eta_2\tau}{\eta_3}. \tag{65}$$

Conversely, when $\tau > \tau_0$, (63) is more stringent and implies that:

$$t < \frac{\eta_4 - \eta_5\tau}{\eta_6}. \tag{66}$$

Conditions (65) and (66) entail relatively low values of interregional transport costs. In this first case, agglomeration in the hub is an equilibrium. Indeed, for any value of $\lambda > \frac{1}{2}$ the indirect utility differential is positive.

This prompts to the first proposition of this paper:

[12] $\tau_0$ is the value of trade costs where the two lines of figure (6) cross.

**Proposition 1 (Transport Costs, Trade Costs and Hub Agglomeration)** *When $\tau < \tau_0$ (respectively $\tau > \tau_0$), for any transport costs values satisfying (65) (respectively (66)), Hub agglomeration is an equilibrium.*

The case where (62) and (63) hold doesn't discard partial agglomeration in the hinterland. Assuming that the values of $\eta_1$ to $\eta_6$ bundles of parameters are such that (54) may be equal to 0, the model admits the following equilibrium

$$\lambda^* = \frac{1}{2} - \frac{(\eta_4 - \eta_5\tau - \eta_6 t)}{2(\eta_1 + \eta_2\tau - \eta_3 t)} \tag{67}$$

with $\lambda^* < \frac{1}{2}$, which implies partial agglomeration in the hinterland.[13] However, as (62) holds this equilibrium is unstable, short deviations from it may drive the economy towards full agglomeration in the hub.

The second subcase corresponds to the situation where conditions (62) and (63) are both violated (Region II in figure (6)), i.e.:

$$(\eta_1 + \eta_2\tau - \eta_3 t) < 0$$
$$(\eta_4 - \eta_5\tau - \eta_6 t) < 0$$

It implies, when $\tau < \tau_0$, transport costs exceeding the upper treshold of condition (66). When $\tau > \tau_0$, it rather implies friction costs above the upper bound of condition (65).

In this case, Hinterland agglomeration may be an equilibrium provided that the indirect utility differential evaluated at $\lambda = 0$ is negative that is:

$$-(\eta_1 + \eta_2\tau - \eta_3 t) + (\eta_4 - \eta_5\tau - \eta_6 t) < 0$$

which implies that

$$\tau > \frac{\eta_4 - \eta_1 + (\eta_3 - \eta_6)t}{\eta_2 + \eta_5} \tag{68}$$

Therefore, high transportation and trade costs induce full agglomeration in the hinterland. Protected by the relative closeness induced by expensive domestic trade and without a good access to international markets, domestic firms prefer locating to the hinterland.

**Proposition 2 (Transport costs, trade costs and agglomeration in the hinterland)** *Any values of transport and trade costs violating both conditions* (62) *and* (63) *and fullfilling condition* (68) *induce Hinterland agglomeration.*

[13] This solution is acceptable (i.e. $\lambda^* > 0$) if trade costs exceed the following treshold: $\tau > \frac{\eta_4 - \eta_1 + (\eta_3 - \eta_6)t}{\eta_2 + \eta_5}$.

If condition (68) doesn't hold, the model admits a spatial distribution, $\lambda^* < 1/2$, implying partial agglomeration in the hinterland. This spatial equilibrium is stable since (62) doesn't hold. Therefore, when trade integration prevails in a context of market fragmentation, a minority of firms remain in hub to benefit from its higher market potential.

**Proposition 3 (Transaction costs and partial agglomeration in the hinterland)** *For any values of transport and trade costs violating both conditions* (62)*,* (63) *and* (68)*, partial agglomeration in the Hinterland is a stable equilibrium.*

We still have to determine when $\eta_1/\eta_3$ is lower than $t_{21}^{trade}$, so that for any transport costs below that treshold, bilateral trade between the two domestic regions is possible. It is the case when the mass of unskilled workers is sufficiently large so that:

$$L > \frac{c\tau H_F\left(6b^2\phi^2 + 6bcH\phi + c^2H^2\right) - 2a\phi\left(6b^2\phi^2 + 8bcH\phi + 3c^2H^2\right)}{c(2b\phi + cH)\left(2a\phi + c\tau H_F\right)}$$

Such a condition is likely to be fullfilled since the fraction of highly educated people represented only 14.3 % of the world total population in 2000 (cfr Barro and Lee (2001, Table 3)).

Propositions (1) and (2) yield opposite results. When trade and transport costs are low, the hub is the preferential location for firms because of its better access to either market. Conversely, when they are high hub firms have only a poor access to the foreign market. Therefore, firms prefer to locate in the hinterland in order to take advantage of the protection granted by high transportation costs.

Proposition (3) describes the spatial equilibrium prevailing in case of trade integration coupled with substantial interregional friction barriers. In this configuration, the hub remains attractive to a minority of firms because of its higher market potentiel. However most of firms will relocate in the hinterland to avoid a fierce price competition.

# 5 Conclusion

In this paper we rely on international trade and gate effects to explain the formation of agglomerations in SSA hubs. According to the two models developed, openness is likely to trigger agglomeration in the hub especially when transport costs are low. This result is consistent with Weber's theory of location (Beckmann and Thisse, 1986) which states that in a star-shaped network without any dominant location, entry points are the optimal locations.[14]

Those results shed light on agglomeration processes in SSA. Indeed, as described in the introduction SSA is characterized by the stability of spatial concentration of economic activities along coastal locations. This persistence of the location of several of its biggest cities in hubs is quite appealing, especially in the context of increasing trade integration facilitated by the increasing efficiency of transport technologies and by the general decrease of tariffs. It discards Krugman and Elizondo (1996)'s model which explains urban concentration in developing countries by backward and forward linkages triggered by import-substitution policies and predicts that urban concentration may shrink with openness. Modeling explicitly locational disadvantages may therefore be one way to provide a convincing explanation of spatial distribution in SSA.

One relevant issue has still to be discussed: the impact of the magnitude of interregional transport costs on agglomeration location. According to the three regions OTT model we developed, increasing trade integration may induce agglomeration on the hub provided that transport costs are not too high. Otherwise, according to Proposition (3), partial agglomeration will take place in the hinterland. The last prediction while intuitive doesn't seem to have been backed by any empirical evidence: in countries of SSA having access to the sea primate cities are located at the hub despite the high transport costs characterizing most of countries of that region. Kenya is the only country where the primate and capital city moved from the port of Mombasa to Nairobi, an interior location. But as Nairobi is the hub of the Kenyan transportation network, this Kenyan exception is not really a genuine one (Obudho, 1997). The model à la OTT would rather imply that firms would have moved to the hinterland to escape from price competition. The persistence of coastal locations of primate city challenges this prediction.

One way to go through that problem is to recall that in the real world all the factors favoring the emergence of urban agglomerations are mixed: political factors, scale economies and locational (dis)advantages as well. It is therefore difficult to find a real situation where hub effects are the only at play. The primate city in a typical african country is often at the same time the capital city, the hub and the nascent industrial center. Therefore, the political and administrative role of primate port cities induces a lock in effect that may explain their persistence in spite of very high transport costs. This argument yields an appeal for a model encapsulating both political and hub effects. We wish to develop it in a future research.

[14]The network we consider here : a segment line with three locations is a degenerate form of a star network.

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# Appendix A: Colonial Capitals in Africa


Figure 7: Colonial Capitals in Africa. Source: Christopher (1994)

## Appendix B: Change in National Capitals


Figure 8: Change in National Capitals, 1900-1991. Source: Christopher (1994)

# Appendix C: FE model market outcome solutions

Replacing net aggregate incomes are given by expression (3), into wage expressions given by (15), (16) and (17) yields the following solutions in $w_0$, $w_1$ and $w_2$:

$$\begin{aligned}
w_0 &= \frac{1}{D(\phi_\tau,\phi_\rho)}\mu\left(-2\sigma^2 H_F^2 L\phi_\rho^2\phi_\tau + \sigma H_D H_F \phi_\rho\left((1-\lambda)(\mu-\sigma)(L+L_F)\right.\right. \\
&\quad -2\lambda\left(\sigma L_D\left(1+\phi_\rho^2\right)+L_F\left(-\mu+2\sigma+\mu\phi_\rho^2\right)\right)\phi_\tau + (-1+\lambda)\left(2L_F\left(\sigma+\mu\phi_\rho^2\right)\right. \\
&\quad \left.\left.+L_D\left(\mu+\sigma+2\sigma\phi_\rho^2\right)\right)\phi_\tau^2\right) + H_D^2\left(-\left(\sigma L_D\phi_\rho^2(-\lambda+(-1+\lambda)\phi_\tau)\left((1-\lambda)(\mu-\sigma)\right.\right.\right. \\
&\quad \left.\left.-2\lambda\sigma\phi_\tau + (-1+\lambda)(\mu+\sigma)\phi_\tau^2\right)\right) + 2L_F\left((1-\lambda)\lambda(\mu-\sigma)\left(-\mu+\sigma+\mu\phi_\rho^2\right)\right. \\
&\quad -\sigma\left((-1-2(-1+\lambda)\lambda)(\mu-\sigma)+\lambda^2\mu\phi_\rho^2\right)\phi_\tau \\
&\quad \left.\left.\left.+(-1+\lambda)\lambda(\mu+\sigma)\left(-\mu+\sigma+\mu\phi_\rho^2\right)\phi_\tau^2 - (-1+\lambda)^2\mu\sigma\phi_\rho^2\phi_\tau^3\right)\right)\right) \\
w_1 &= \frac{1}{D(\phi_\tau,\phi_\rho)}\mu\left(-2\sigma H_F^2\phi_\rho\left(\sigma L_F\phi_\rho^2 + L_D\left(-\mu+\sigma+\mu\phi_\rho^2\right)\right)\phi_\tau\right. \\
&\quad -\sigma H_D^2\phi_\rho(-\lambda+(-1+\lambda)\phi_\tau)\left((1-\lambda)(\mu-\sigma)(L+L_F) - 2\lambda\sigma L\phi_\tau\right. \\
&\quad \left.+(-1+\lambda)((\mu+\sigma)L_D+2\mu L_F)\phi_\tau^2\right) + H_D H_F\left((-1+\lambda)(-\mu+\sigma)\left(2\sigma L_F\phi_\rho^2\right.\right. \\
&\quad \left.+L_D\left(-\mu+\sigma+\mu\phi_\rho^2\right)\right) - 2\lambda\sigma\left(2\sigma L_F\phi_\rho^2 + L_D\left(-\mu+\sigma+(\mu+\sigma)\phi_\rho^2\right)\right)\phi_\tau \\
&\quad \left.\left.+(-1+\lambda)\left(2\sigma(\mu+\sigma)L_F\phi_\rho^2 + L_D\left(-\mu^2+\sigma^2+\left(\mu^2+\mu\sigma+2\sigma^2\right)\phi_\rho^2\right)\right)\phi_\tau^2\right)\right) \\
w_2 &= \frac{1}{(\lambda-1)D(\phi_\tau,\phi_\rho)}\left(-L_D - \sigma\left(H_F\phi_\rho\phi_\tau + H_D(1-\lambda+\lambda\phi_\tau)\right)\left(\sigma(-\mu+\sigma)H_F^2 L_D\phi_\rho\right.\right. \\
&\quad +\sigma H_D^2\phi_\rho(-\lambda+(-1+\lambda)\phi_\tau)\left(\lambda(\mu-\sigma)L_D + (-1+\lambda)((\mu+\sigma)L_D+2\mu L_F)\phi_\tau\right) \\
&\quad +H_D H_F\left(\lambda(\mu-\sigma)L_D\left(\mu-\sigma-(\mu+\sigma)\phi_\rho^2\right) - (-1+\lambda)\left(2\mu\sigma L_F\phi_\rho^2\right.\right. \\
&\quad \left.\left.\left.\left.+L_D\left(-\mu^2+\sigma^2+\left(\mu^2+\sigma^2\right)\phi_\rho^2\right)\right)\phi_\tau\right)\right)\right)
\end{aligned}$$

where

$$\begin{aligned}
D(\phi_\tau,\phi_\rho) &= 2(\mu-\sigma)\left(\sigma^2 H_F^3\phi_\rho^2\phi_\tau + \sigma H_D^3\phi_\rho(-\lambda+(-1+\lambda)\phi_\tau)\left((1-\lambda)\lambda(\mu-\sigma)\right.\right. \\
&\quad \left.-(1+2(-1+\lambda)\lambda)\sigma\phi_\tau + (-1+\lambda)\lambda(\mu+\sigma)\phi_\tau^2\right) \\
&\quad +\sigma H_D H_F^2\phi_\rho\left((-1+\lambda)(\mu-\sigma)+\lambda\left(-\mu+2\sigma+(\mu+\sigma)\phi_\rho^2\right)\phi_\tau\right. \\
&\quad \left.-(-1+\lambda)\left(\sigma+(\mu+\sigma)\phi_\rho^2\right)\phi_\tau^2\right) + H_D^2 H_F\left((\mu-\sigma)\left((1-\lambda)\lambda(\mu-\sigma)\right.\right. \\
&\quad \left.-(1+2(-1+\lambda)\lambda)\sigma\phi_\tau + (-1+\lambda)\lambda(\mu+\sigma)\phi_\tau^2\right) \\
&\quad +\phi_\rho^2\left((-1+\lambda)\lambda(\mu-\sigma)(\mu+\sigma)+\phi_\tau\left(\sigma\left(\sigma-2\lambda\sigma+\lambda^2(\mu+3\sigma)\right)\right.\right. \\
&\quad \left.\left.\left.\left.+(-1+\lambda)\phi_\tau\left(-\left(\lambda\left(\mu^2+2\mu\sigma+3\sigma^2\right)\right)+(-1+\lambda)\sigma(\mu+\sigma)\phi_\tau\right)\right)\right)\right)\right)
\end{aligned}$$

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