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INTEGRATION, AGGLOMERATION AND SPECIALIZATION: THE ROLE OF FACTOR MOBILITY

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Integration, Agglomeration and Specialization: The Role of Factor Mobility

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Abstract / Résumé

This paper addresses the question of what determines the industrial specialization of initially similar countries. More specifically, it expands current models in the New Economic Geography literature by introducing a clear distinction between agglomeration of industrial activities and sectoral concentration leading to industrial specialization of countries. This point is the first insight of the paper as the two dimension—agglomeration and specialization—are often confused in this literature as in Krugman [1991b] and Krugman and Venables [1995]. We describe a process in which there is an increasing specialization as integration proceeds associated with non-monotonic agglomeration where the core first gains activity and then loses. A non monotonic evolution of sectoral allocation underlies this evolution of aggregate activity. Reduction in trade costs may increase the incentive to locate in the small country which presents a comparative advantage in term of factor costs. This advantage arises endogenously during the integration process. The second insight introduces a distinction between a dispersion process in which the aggregate activity disperses and a re-dispersion process in which only one sector moves from the core to the periphery.

JEL Classification: F12; R12; F15

Keyword: Agglomeration, Specialization, Integration, Mobility, Linkages

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Dans la littérature de la Nouvelle Économie Géographique (NEG), le regroupement des activités à rendements croissants émerge de processus cumulatifs. Ces derniers sont dépendants des hypothèses de mobilité des facteurs de production ou de l’existence de relations clients-fournisseurs entre les firmes. Outre le fait de donner corps à ces processus, le choix de ces hypothèses conditionne les conclusions des modèles et les effets attendus des processus d’intégration économique. Trois grands schémas peuvent alors être identifiés. Le premier, dans la lignée des modèles fondateurs de la NEG, met en avant une agglomération des activités à rendements croissants dans une seule entité géographique. Le second, sous l’hypothèse d’immobilité des travailleurs, offre une conclusion moins pessimiste puisque si des disparités émergent au cours du processus d’intégration, celles-ci ne sont que transitoires. Enfin, un troisième schéma, dans le cadre de modèles multisectoriels et toujours sous l’hypothèse d’immobilité des facteurs de production, permet d’illustrer les mécanismes qui sous-tendent les processus de spécialisation industrielle.

Si chacune des hypothèses fondant les modèles de la NEG, aussi bien que les conclusions auxquelles elles conduisent, renvoie à des réalités différentes, rien n'implique qu'elles doivent s'exclure mutuellement. En effet, différents arguments plaident en faveur d'une combinaison à la fois de ces hypothèses et des schémas de répartition auxquels elles renvoient.

Ainsi, en Europe, si les travailleurs apparaissent peu mobiles, il ne s'agit là que d'une tendance générale et l'hypothèse peut être affinée notamment en supposant que les secteurs industriels combinent dans leur production, des facteurs à la mobilité différente. Ce dernier point peut être illustré en se fondant sur le fait que la mobilité des travailleurs varie en fonction de leur degré de qualification, les travailleurs qualifiés apparaissant relativement plus mobiles que les travailleurs non qualifiés[1].

Comme les différents comportements face à la mobilité appellent à une analyse plus fine des facteurs de production, l'évolution de la répartition des secteurs appelle à une analyse plus fine du secteur industriel, amenant d'emblée à rejeter l'hypothèse d'un secteur homogène. En effet, trois tendances peuvent simultanément être observées. Premièrement, le degré de concentration diffère d'un secteur à l'autre. Deuxièmement, les secteurs ne se concentrent pas tous dans les mêmes pays, pas plus qu'ils ne le font de façon synchrone. Enfin, la taille et la structure industrielle diffèrent d'un pays à l'autre. Cela suggère qu'il existe à la fois des forces d'agglomération au sein d'un secteur mais aussi des forces d'agglomération d'intensité différente entre secteurs. Nous les distinguons en faisant référence à des forces de concentration et d'agglomération.

Les forces de concentration tiennent au fait que les *inputs* sont spécifiques à un même secteur, les firmes appartenant à ce secteur ont alors un intérêt à se regrouper géographiquement comme cela est le cas dans les modèles de la NEG. L'intensité de ces forces est alors déterminée par l'importance que tiennent les biens intermédiaires dans la fonction de production des firmes. Corrélativement, des firmes sans liaison *input-output* n'ont pas d'intérêt à se localiser à proximité du fait de la concurrence sur le marché du facteur immobile.

Introduire la force d'agglomération via le marché des biens intermédiaires en supposant que des firmes de secteurs différents puissent avoir des relations clients-fournisseurs n'apparaît pas satisfaisant. En effet, l'enjeu porterait sur l'intensité relative des liaisons inter et intrasectorielles, impliquant de fait une alternative entre force de concentration et d'agglomération. En revanche et en acceptant l'idée de secteurs industriels utilisant

[1] De façon certainement encore plus marquée, il semble que l'on puisse opposer l'immobilité des travailleurs avec la mobilité du capital, ce que nous proposons dans un autre document de recherche présentant une version modifiée du modèle exposé ci-après.

un même facteur de production immobile, c'est par le marché de ce facteur que les secteurs pourront se trouver liés, à la fois par les coûts que représente ce facteur mais aussi par le revenu qu'il génère et la demande qu'il engendre sur le marché des biens finals.

Ces différents points nous amènent à proposer ici un modèle d'économie géographique combinant les hypothèses standards de mobilité et non-mobilité des facteurs, permettant de rendre compte simultanément des phénomènes d'agglomération et de concentration. De plus, en envisageant uniquement des secteurs industriels, notre réflexion s'inscrit dans une logique de spécialisation industrielle sans pour autant faire abstraction des forces d'agglomération.

INTRODUCTION

The general proposition underlying this paper is that the consequences of integration on spatial allocation of economic activities are not as simple as generally posited in the New Economic Geography (NEG) literature.

In this literature, initiated by Paul Krugman contribution's in the early 1990', typical models assume one manufacturing sector producing under increasing returns to scale (IRS) and one traditional sector, perfectly competitive. Hence, during an integration process two main predictions can be identified. The first one is a monotonic evolution of the agglomeration of the industry in one location. Then agglomeration induces specialization of this core region in IRS activity and of the periphery in the traditional sector. In later contributions (following *Krugman and Venables [1995]*) assuming factor immobility, the authors conclude that a deeper integration may induce the re-dispersion of the industrial activity in the periphery, giving rise to the now traditional *U-Shape* relation, between integration and agglomeration. If these second set of conclusions points to the convergence of industry size for sufficiently low trade costs, the confusion between agglomeration of the industrial sector and the specialization of the core in this activity still remains.

No matter the hypothesis on factor mobility, most NEG models posit an opposition between specialization in the IRS sector and in the traditional one, the main focus of these contributions is the impact of integration on the industrialization of countries and the emergence of a core-periphery schema. Once we consider that the IRS activity is composed of different sectors and that countries may specialize in different IRS sectors, such predictions are no longer satisfactory.

Such a reduction in the presentation of NEG results is certainly too short. As an example *Krugman and Venables [1996]* introduce the specialization problem in the NEG literature. If they are able to describe a specialization of different countries in different IRS sectors, this process is underlined by a monotonic process of sectors concentration. Furthermore, in their contribution the question of agglomeration, in the sense of a difference in the size of industry between countries, disappears.

However empirical evidence seems to support the relevance of both an agglomeration effect and a process of specialization, for example in Europe (*Amiti [1999]*, *Midelfart - Knarvik et al. [2000] WIFO [1999]*). Moreover, these results on the spatial allocation of aggregate activity are completed by evidence of a non-monotonic process of concentration of sectors in the core. In summary, industrial sectors seem to concentrate in the core in the first stage of integration and some of them re-disperse in the periphery after further integration (*Amiti [1998; 1999]*, *Brülhart and Torstensson [1996]*, *Brülhart [1996*; *1998a]*).

Following from the preceding presentation of contributions focusing on specialization process, the introduction of a multiplicity of IRS sectors seems not to be sufficient to describe a plausible process of specialization. There is a need to introduce heterogeneous components in the economy. Some contributions follow this line, assuming initial differences between countries (see for example *Amiti [2005]*, *Ricci [1999]*, *Epifani [2005]*). If this approach is certainly relevant, it gives rise to an unsatisfactory outcome because it reintroduces components that the NEG seeks to abstract: typically “first nature” determinants.

The aim of this paper is to examine the relation between agglomeration and specialization within sectors subject to IRS in a standard NEG model, abstracting from any initial advantage and relying on a process of endogenous creation of such an advantage.

With this in mind, we combine standard hypothesis of mobile and non-mobile factors of production, both of them being used in production which is carried out by two different IRS sectors. Furthermore, we assume that firms in each of these sectors are linked by input-output relations. It is from the use of factors that differs in mobility that international differences in production cost endogenously emerge. The allocation of economic activity will result from this difference.

The model we present allows us to describe the consequences of integration along two main dimensions. Agglomeration; which refers to the distribution of aggregate activity. Concentration; which refers to the spatial allocation of each sector. This dimension is strongly tied to an approach in terms of sectoral composition of location, which refers to specialization.

As trade costs are reduced, the spatial allocation of activity will evolve as follows:

When trade costs are high, firms evenly spread between countries to supply local demand at low costs, hence there is neither agglomeration nor specialization. For intermediate values of trade costs, returns to scale and demand linkages (both finale and intermediate) interact with crowding effects (both on product market and factor market) and transport cost to shape a diversified core and a specialized periphery. At low trade costs, for a sufficiently integrated economy, each sector concentrates in one location, hence specialized countries.

The rest of the paper is organized as follow; Section 2 describes and set out the formal model. Section 3 solves for equilibrium. Section 4 presents the results for concentration, specialization and agglomeration pattern. Section 5 concludes.

1. THE MODEL

Our framework departs from traditional NEG models—*two countries, two sectors*—in a few respects. In the literature, the typical model assumes a traditional sector and only one manufacturing sector which includes all the production of manufactured goods. Because we wish to deal with industrial specialization we exclude the agricultural sector and suppose that there are two industrial sectors $(s = 1,2)$.

We assume that the production of these two goods requires unskilled workers, different kind of skilled workers (one for each sector in this simplest case) and an intermediate input produced by the same sector as the firm that uses it, giving rise to intra-industry linkages.[2] We assume that these factors are not used in the same proportion in the two industries. This does not seem unrealistic since the computer industry is for example more intensive in skilled workers than textile industry. Skilled and unskilled workers do not have the same behavior in term of migration. It is assumed that unskilled labor is not mobile between countries but can be used in both sectors. On the contrary, skilled labor is supposed sector specific but can migrate between countries in response to a real wage differential. Thus, there exists a country specific endowment of unskilled labor, which has to be allocated between sectors operating in the country and a world endowment of each kind of skilled workers which has to be allocated between countries in response to real wage differentials. The basic reason for this set of assumptions is that specific industries require specific skills, and special training is required to become skilled. Changing profession is costly for a skilled worker. Furthermore, skilled workers are known to be more mobile than unskilled workers (*Shields and Shields [1989]*, *Greenwood [1997]*…). Moreover this assumption is in line with a traditional assumption in NEG literature which posit worker immobility between traditional and manufacturing sector.

We consider a world with two countries Home and Foreign, $(\tilde{\ })$ denotes a foreign variable. The countries are supposed identical, both have access to the same technology, and consumers in each country have identical homothetic preferences. Finally the number of unskilled and skilled workers is initially identical in both countries. As usual in NEG literature this hypothesis posits that the mobile factors are evenly split between countries. Therefore, there is no "first nature" location advantage in the model.

For convenience we suppose the amount of unskilled workers in each country, normalized at 1 ($L = \widetilde{L} = 1$). In the same way we suppose the same number of skilled

[2] In a two sectors economy, allowing firms to use output from the other sector may change quantitative results but not qualitative ones as long as intra-industrial linkages are strongest than inter-industrial linkages.

workers of each type in the world, let say one (1). We denote the share of skilled labor of type *s* in Home (Foreign) country by h_s, ($\tilde{h}_s$) with $h_s + \tilde{h}_s = H_s = 1$.

In the next sub-sections we specify the equations of the model for the Home country. Note that the same equations hold for the Foreign country.

1.1 Consumers

The aggregate utility function *U*, for the representative consumer is Cobb-Douglas

$$U = \sum_s C_s^{\mu_s}, \ \sum_s \mu_s = 1 \tag{1}$$

Where C_s, $(s = 1,2)$ is aggregate consumption of manufactured good of sector s. Let n_s and $\tilde{n}_s$ be the size of the continuum of varieties of sector s produced in Home and Foreign country. The aggregate demand C_s for manufacturing good produced by sector s is defined as

$$C_s = \left[\int_{i=1}^{n} c_s(i)^{(\sigma-1)/\sigma} di + \int_{j=1}^{\tilde{n}} \left(\frac{m_s(j)}{\tau}\right)^{(\sigma-1)/\sigma} dj\right]^{\sigma/(\sigma-1)} \tag{2}$$

Domestic consumer demand for each variety produced domestically is given by $c_s(i)$ and demand for imported variety by $m_s(j)$, σ is the elasticity of substitution between two varieties which is supposed to be the same for the two sectors. This elasticity is finite when sectors produce a differentiated good. Firms in both sectors incur positive costs when selling in a foreign market. To model transport cost, we adopt the usual *iceberg* technology: in order to sell in a particular country one unit of sector *s*' output manufactured in the other country, a firm must export $\tau > 1$ units. If $\tau = 1$ there is free trade and if $\tau \to \infty$ there is no trade.

Dual to quantity index for manufactured good, the price index G_s is

$$G_s = \left[\int_{i=1}^{n} p_s(i)^{1-\sigma} di + \int_{j=1}^{\tilde{n}} \left(\tilde{p}_s(j)\tau\right)^{1-\sigma} dj\right]^{1/(1-\sigma)} \tag{3}$$

Where $p_s(i)$ is the producer price of variety *i* of good *s* (mill price) and $\left(\tilde{p}_s(j)\tau\right)$ the delivered price of variety *j* of the good *s* including trade costs.

1.2 Industry

Each of the two different manufacturing sectors is assumed to be monopolistically competitive *à la Dixit and Stiglitz [1977]*, producing under increasing return to scale a large number of differentiated goods using the three factors of production previously described.

More specifically, in sector *s*, producing quantity q_s of any variety in any country requires the same amount fixed *F* and variable *c* quantities of production input. Note that the existence of fixed cost gives rise to increasing returns technology and it is assumed that the size of *F* is small enough to ensure that the number of varieties produced is large enough to make oligopolistic interactions negligible. The input, used in sector *s*, is a Cobb-Douglas composite of unskilled labor, specific skilled labor and an aggregate of the differentiated industrial good produced by sector *s*.[3] In Home country the production function for each variety of sector *s* good is

$$L(i)^{\alpha_s(1-\gamma_s)} h_s(i)^{(1-\alpha_s)(1-\gamma_s)} C_s^{\gamma_s} = F + cq_s(i) \tag{4}$$

Where $L(i)$ and $h_s(i)$ are respectively the unskilled labor and skilled labor amount employed by a typical firm of sector *s* to produce output $q_s(i)$. C_s is a quantity index aggregated across varieties of sector *s* input, as defined by equation (2). γ_s is the share of the intermediate input in the production function. We suppose sector 1 is more intensive in industrial goods than sector 2, hence $\gamma_1 > \gamma_2$. This hypothesis introduces an asymmetry in the sector response to a change in the transport cost. α_s (*resp* $(1-\alpha_s)$) is the share of unskilled labor (resp skilled labor) used in the production of sector *s*.

Profit of each firm is given by total revenue less total cost.

$$\Pi_s(i) = p_s(i) q_s(i) - W^{\alpha_s(1-\gamma_s)} w_s^{(1-\alpha_s)(1-\gamma_s)} G_s^{\gamma_s} (F + cq_s) \tag{5}$$

Where W is the wage earn by unskilled workers in Home country (the same in both sector), w_s is the wage earn by skilled workers and G_s the price index of industrial good defined as in equation (3).

We assume there is free entry and exit in both sector leading to zero profit.

[3] As usual in the literature, the assumed elasticity of substitution among varieties of manufacture is the same for firms as it is for consumers, so the price index for intermediates facing producers in Home country is the same as the one given for consumers in equation (3).

2. EQUILIBRIUM ANALYSIS

As usual, we describe equilibrium analysis in three steps. First we solve the representative consumer's utility maximization problem to derive the final demand for industrial goods of each type. Second we solve the i^{th} firm's profit maximization problem in each sector *s* to derive producer prices, and each firm's demand for intermediate inputs. Using the free entry and exit condition we derive the number of units each manufacturing firm must produce to break-even. Third we determine product market clearing conditions and solve the factor market clearing conditions.

2.1 Consumers

In each country the final demand for manufacturing goods came from skilled and unskilled workers who have the same utility function given by equation (1).

The representative consumer (of each type) utility maximizing problem is solved using a two-stage budgeting. In stage one, the consumer allocates expenditure between industrial sectors by maximizing the utility function (equation (1)), subject to the budget constraints y, which could be the revenue earned by unskilled (WL) or by skilled workers of a particular type ($w_s h_s$), which is given by the wage of the specific factor and the share of this factor allocated in the country

Then

$$C_s G_s = \mu_s y \quad , \quad \sum_s \mu_s = 1 \tag{6}$$

In stage two, the consumer maximizes the sub-utility function C_s (equation (2)) subject to the budget constraints $\mu_s y$ in equation (6), to derive the demand function for each variety of manufactured good *i* produced by sector *s* in Home country and each imported variety *j* produced in the Foreign country, respectively:

$$c_s(i) = p_s(i)^{-\sigma} \, G_s^{1-\sigma} \mu_s \, Y \tag{7}$$

$$m_s(j) = \tau^{1-\sigma} \, \tilde{p}_s(j)^{-\sigma} \, G_s^{1-\sigma} \mu_s \, Y \tag{8}$$

This gives the final demand for industrial goods of each type, with $Y = WL + w_1 h_1 + w_2 h_2$.

2.2 Firms

We consider now the firms behavior in each manufacturing sector. In the manufacturing sector, firms choose a variety *i* and pricing so as to maximize profits, taking as given the variety choice and pricing strategy of the other firms in the industry. Each firm will produce a distinct variety since it can always do better by introducing a new product variety than sharing in the production of an existing one. In sector *s* each firm maximizes profit with respect to quantity to derive producer price

$$\frac{\partial \Pi_s(i)}{\partial q_s(i)} = 0 \Rightarrow \ p_s(i) = \frac{c\sigma}{\sigma - 1} W^{\alpha_s(1-\gamma_s)} w_s^{(1-\alpha_s)(1-\gamma_s)} G_s^{\gamma_s}$$

This give the usual marginal revenue equals marginal cost condition, with price as a constant mark up over marginal cost. We choose units of measurement so that $c = \left(\sigma - 1/\sigma\right)$ then the price expression reduces to

$$p_s(i) = W^{\alpha_s(1-\gamma_s)} w_s^{(1-\alpha_s)(1-\gamma_s)} G_s^{\gamma_s} \tag{9}$$

A proportion $\alpha_s\left(1-\gamma_s\right)$ of *s* industry's revenue is spent on unskilled labor, $\left(1-\alpha_s\right)\left(1-\gamma_s\right)$ on skilled labor and γ_s on intermediate input. Hence expenditure on industry *s*, coming from firms in the same industry, is given by $I = \gamma_s n_s p_s$. The demand function, as an intermediate input, for each variety of manufactured good *i* produced by sector *s* in Home country and each imported variety *j* produced in the Foreign country, are given by:

$$c_s\left(i\right) = p_s\left(i\right)^{-\sigma} G_s^{1-\sigma} I_s \tag{10}$$

$$m_s\left(j\right) = \tau^{1-\sigma} \tilde{p}_s\left(j\right)^{-\sigma} G_s^{1-\sigma} I_s \tag{11}$$

As described before the consumer allocates a share μ_s of his income on each sector. So the total expenditure (E_s) on industry *s* coming from both final consumer and firms could be defined as the sum of the finale and the intermediate expenditure and it is given by $E_s = \mu_s Y + I_s$.The demand function for each variety *i* of sector *s* produced in Home country and variety *j* imported from Foreign country are then given by

$$c_s(i) = p_s(i)^{-\sigma} G_s^{\sigma-1} E_s \tag{12}$$

$$m_s(j) = \tau^{1-\sigma} \tilde{p}_s(j)^{-\sigma} G_s^{\sigma-1} E_s \tag{13}$$

We can derive the number of varieties produced in each industry by imposing the free entry and exit condition, which leads to zero profits. This condition determines the quantity of output required to cover the fixed cost. With $\Pi_s(i) = 0$,

$$q_s(i) = \frac{\sigma - 1}{c} F \tag{14}$$

Without loss of generality, firm size is scaled so that profits are equal to zero at size 1, by setting $F = 1/\sigma$. Note that equilibrium scale of output is independent of price and of number of firms. This is a direct consequence of *Dixit and Stiglitz [1977]* preferences and a constant elasticity of substitution. Then the complementary slack condition implies that at least one of the following conditions holds with equality

$$q_s(i) \leq 1, \quad n_s \geq 0, \quad s = 1,2$$

2.3 Product and Factor Markets

Product market equilibrium requires that demand equals supply for each good in each industry

$$q_s(i) = c_s(i) + \widetilde{m}_s(j)$$

giving

$$q_s = (p_s)^{-\sigma} \left[E_s G_s^{(\sigma-1)} + \widetilde{E}_s \widetilde{G}_s^{(\sigma-1)} \tau^{(1-\sigma)} \right] \tag{15}$$

To describe the factor market clearing conditions we must be aware that the conditions for the unskilled labor market must hold at a country level for the two sectors. Indeed this factor must be allocated between the two sectors operating in a country. On the other hand, the skilled market clearing conditions must hold for one type of this factor at the world level. The factors market equilibrium conditions are then given by

$$L = \alpha_1 (1 - \gamma_1) n_1 p_1 W^{-1} + \alpha_2 (1 - \gamma_2) n_2 p_2 W^{-1} \tag{16}$$

$$\begin{aligned} w_1 h_1 &= (1 - \alpha_1)(1 - \gamma_1) n_1 p_1 \\ \widetilde{w}_1 \tilde{h}_1 &= (1 - \alpha_1)(1 - \gamma_1) \tilde{n}_1 \tilde{p}_1 \end{aligned} \tag{17}$$

This factor can migrate, so at equilibrium there must be equality between real skilled wages at world level:

$$w_s \sum_s G_s^{-\mu_s} = \widetilde{w}_s \sum_s \widetilde{G}_s^{-\mu_s}, \quad \sum_s \mu_s = 1 \tag{18}$$

These equations will form the basis for analyzing the effects of trade liberalization on the allocation of economic activity. This allocation will be the result of the opposition of the centripetal and centrifugal forces. Centripetal forces are due to the backward and forward linkages: firms producing under monopolistic competition tend to locate close to both the final and intermediate large markets. The centrifugal forces came from the crowding market effect within each sector and the competition effect on the immobile factor market which act within as well as across sectors. Furthermore, this last effect has an ambiguous consequence for location choice since at the same time it rises the cost of production and wages and so demand in a country.

3. RESULTS

We are interested in the model's predictions in terms of the evolution of the spatial allocation of economic activity during an integration process. In particular, three kinds of allocation could be distinguished: agglomeration, concentration and dispersion. To clarify the definition of these three configurations let retain the criteria of the number of skilled workers in each country. Using the number of firms as criteria will not affect the definition. *Agglomeration* means that a country receives a bigger part of mobile workers. Then there is agglomeration in the Home country if $AGG = h_1 + h_2 > 1$.[4] *Concentration* means that a particular country receives more than half of the mobile workers of a particular type, then different regimes of concentration could be distinguished. First, a full concentration configuration in which each country receives the world endowment of one kind of mobile factor. This configuration induces a full specialization of countries. Second, a partial concentration in which more than a half of the world endowment of one kind of mobile workers is located in one country, the other kind of workers being (evenly or not) split between the two countries. Finally, *dispersion* defines a situation in which both the mobile factors are evenly split between countries. In the rest of the paper we will study the occurrence of these different configurations.

Beyond our interest in the evolution of the spatial allocation of the activity, we'll pay attention to the impact of factor intensity on this evolution.

As usual in NEG literature, we begin by studying two particular configurations. The first one supposes that the skilled workers of each type and so the sector that uses it, are fully concentrated in one country leading to a specialized configuration. In the second one we assume the skilled labor of each type evenly split between countries. The study of these two configurations will help us to get insight of the determinant and the relative intensity of the forces shaping the spatial allocation of activity. In a third step we'll study a configuration in which there is no assumption about the initial sectoral repartition. If the first goal of this part is to deepen our understanding of the location forces it also allows us to introduce in a simple NEG model a distinction between a dispersion process in which all the industrial activity relocates from a core-periphery situation and a re-dispersion process in which only one sector relocates, leading to the country specialization.

3.1 Sustainability of a Specialized Equilibrium

In this sub-section we assume that the world economy initially exhibits a specialized pattern. This mean that all workers of type 1, and so the sector which uses this factor are

[4] Note that due to the existence of the immobile factor, a total agglomeration is not a possible outcome.

fully concentrated in the Home country. At the same time we assume that the specific labor of sector 2 and so the activity of this sector is concentrated in the Foreign country.[5] This specialized configuration could be summarized by taking into account that the share of mobile workers of each type in each country are such as $h_1 = \tilde{h}_2 = 1;\ \tilde{h}_1 = h_2 = 0$. We are interested to know if such a configuration is an equilibrium. A way to check this is to study if there are incentives for a firm to deviate from this situation. Specifically we must calculate if it is possible for a firm in sector 1 (sector 2) moving from its current location to produce a higher quantity in Foreign (Home) country than the equilibrium quantity it actually produced.

Before determining the sustain point values, some elements must be highlighted. Due to the asymmetry in industrial linkages the value of trade cost for which each sector could be concentrated differs between sectors. So, the sustain point analysis must be made in different steps. In the first one and as usual in the literature we suppose that the two sectors are fully concentrated and we determine the value of trade cost for which there are no incentive to deviate. Not surprisingly, we will demonstrate that the sustain point value in sector 1 occurs for higher values of trade cost. Then by taking into account of this difference, we identify a range of trade cost for which sector 1 could be concentrated while sector 2 could not, inducing a recalculation of the value of trade cost for which sector 1 could be concentrated while sector 2 spread between countries. We then show that in this case the sustain point value is lower than in the preceding one. This result is easily understood. When taking into account the demand on the immobile factor market emanating from firms in sector 2, the concentration of sector 1 can intervene only for lower values of trade cost. This point allows us to shed light on the role of the immobile factor on location choice. Finally in a third step we reverse the reasoning and we ask the question on where is located the sector 2 and how evolves this location when trade cost lie between the values for which sector 1 is fully concentrated but sector 2 is not. This last point introduces the dimension of agglomeration in the study.

> **Proposition 1:** Taking as a point of departure a fully concentrated situation, we show that the sustain point occurs in sector 1 for a higher value of trade cost than in sector 2. Furthermore we show that for sufficiently low value of trade cost the sustainability of a fully concentrated situation is influenced by the intensity in immobile factor. Precisely there could be an incentive for the more intensive sector in this factor to deviate.

With all firms from sector 1 producing in Home country and all firms from sector 2 producing in Foreign country, the precedent model could be simplified:

[5] The study of an equilibrium in which the concentration of each sector occurs in the other country (sector 1 in Foreign and sector 2 in Home) is entirely symmetrical.

Price indexes reduce to

$$\begin{aligned} G_1 &= \left[n_1 p_1^{1-\sigma}\right]^{1/(1-\sigma)} \\ G_2 &= \left[\tilde{n}_2 \left(\tilde{p}_2 \tau\right)^{1-\sigma}\right]^{1/(1-\sigma)} = \tau \widetilde{G}_2 \\ \widetilde{G}_1 &= \left[n_1 \left(p_1 \tau\right)^{1-\sigma}\right]^{1/(1-\sigma)} = \tau G_1 \\ \widetilde{G}_2 &= \left[\tilde{n}_2 \tilde{p}_2^{\,1-\sigma}\right]^{1/(1-\sigma)} \end{aligned} \tag{19}$$

Demand for the output of each firm in each sector in both the Home and Foreign country and for a potential deviant locating in Home and Foreign country are respectively, by equations (15) and (19)

$$q_1 = \frac{E_1 + \widetilde{E}_1}{n_1 p_1} = q_1^*; \qquad \tilde{q}_1 = \left(\frac{\tilde{p}_1}{p_1}\right)^{-\sigma} \left[\frac{E_1 \tau^{1-\sigma} + \widetilde{E}_1 \tau^{\sigma-1}}{n_1 p_1}\right] \tag{20}$$

$$\tilde{q}_2 = \frac{E_2 + \widetilde{E}_2}{\tilde{n}_2 \tilde{p}_2} = q_2^*; \qquad q_2 = \left(\frac{p_2}{\tilde{p}_2}\right)^{-\sigma} \left[\frac{\widetilde{E}_2 \tau^{1-\sigma} + E_2 \tau^{\sigma-1}}{n_2 p_2}\right] \tag{21}$$

Where relative prices can be derived from equations (9) and (19)

$$\frac{\tilde{p}_1}{p_1} = \left(\frac{\widetilde{W}}{W}\right)^{\alpha_1(1-\gamma_1)} \left(\frac{\widetilde{w}_1}{w_1}\right)^{(1-\alpha_1)(1-\gamma_1)} \tau^{\gamma_1} \tag{22}$$

$$\frac{p_2}{\tilde{p}_2} = \left(\frac{W}{\widetilde{W}}\right)^{\alpha_2(1-\gamma_2)} \left(\frac{w_2}{\widetilde{w}_2}\right)^{(1-\alpha_2)(1-\gamma_2)} \tau^{\gamma_2} \tag{23}$$

Substituting equations (22) and (23) into equations (20) and (21), eliminating $n_1 p_1$ and $n_2 p_2$, the ratio of a deviant firm's demand to the zero profit level of output can be expressed as

$$\frac{\tilde{q}_1}{q_1^*} = \left(\frac{\widetilde{W}}{W}\right)^{-\sigma\alpha_1(1-\gamma_1)} \left(\frac{\widetilde{w}_1}{w_1}\right)^{-\sigma(1-\alpha_1)(1-\gamma_1)} \tau^{1-\sigma(1+\gamma_1)} \left[1 + \frac{\widetilde{E}_1}{E_1 + \widetilde{E}_1}\left(\tau^{2(\sigma-1)} - 1\right)\right] \tag{24}$$

$$\frac{q_2}{q_2^*} = \left(\frac{W}{\widetilde{W}}\right)^{-\sigma\alpha_2(1-\gamma_2)} \left(\frac{\widetilde{w}_2}{w_2}\right)^{-\sigma(1-\alpha_2)(1-\gamma_2)} \tau^{1-\sigma(1+\gamma_2)} \left[1 + \frac{E_2}{E_2 + \widetilde{E}_2}\left(\tau^{2(\sigma-1)} - 1\right)\right] \tag{25}$$

Expressions (24) and (25) still depend on skilled wage, unskilled wage and manufacturing expenditure levels, which are endogenous.

To simplify the expression of the output produced by a deviant firm, first consider that at equilibrium by expressions (18) and (19) we have

$$\begin{aligned} \frac{\widetilde{w}_1}{w_1} &= \frac{G_1^{\mu_1} G_2^{\mu_2}}{\widetilde{G}_1^{\mu_1} \widetilde{G}_2^{\mu_2}} = \tau^{\mu_2 - \mu_1} \\ \frac{w_2}{\widetilde{w}_2} &= \frac{\widetilde{G}_1^{\mu_1} \widetilde{G}_2^{\mu_2}}{G_1^{\mu_1} G_2^{\mu_2}} = \tau^{\mu_1 - \mu_2} \end{aligned} \tag{26}$$

To simplify these expressions and because we are not interested in the consequence of a final demand bias, we assume for the rest of the paper that $\mu_1 = \mu_2 = 0.5$.

To solve explicitly for each region's equilibrium share of manufacturing expenditure and unskilled wage as a function of parameters, we have to remember that in each country the unskilled and skilled wage bills are respectively a fraction $\alpha_s (1-\gamma_s)$ $\left((1-\alpha_1)(1-\gamma_1)\right)$ of the value of the output, then the factor market clearing conditions reduce to

$$L = \alpha_1 (1-\gamma_1) n_1 p_1 W^{-1}; \;\; \tilde{L} = \alpha_2 (1-\gamma_2) \tilde{n}_2 \tilde{p}_2 \widetilde{W}^{-1} \tag{27}$$

$$w_1 = (1-\alpha_1)(1-\gamma_1) n_1 p_1; \;\; \widetilde{w}_2 = (1-\alpha_2)(1-\gamma_2) \tilde{n}_2 \tilde{p}_2 \tag{28}$$

and expenditure on each sector coming from each countries in the case of complete concentration are given by

$$\begin{aligned} &E_1 = \mu_1 (WL + w_1 h_1) + \gamma_1 n_1 p_1; \quad E_2 = \mu_2 (WL + w_1 h_1) \\ &\widetilde{E}_1 = \mu_1 \left(\widetilde{W}\tilde{L} + \widetilde{w}_2 \tilde{h}_2\right); \quad \widetilde{E}_2 = \mu_2 \left(\widetilde{W}\tilde{L} + \widetilde{w}_2 \tilde{h}_2\right) + \gamma_2 \tilde{n}_2 \tilde{p}_2 \end{aligned} \tag{29}$$

Taking into account that in each country, the output of the sector in which it is specialized meets total demand for this sector –which can be seen in equations (20) and (21)- the system formed by equations (19), (27)-(29) can be solved giving an expression of the wage of skilled and unskilled workers and the relative demand as a function of the parameters of the model in the case of total specialization (these expressions are given in appendix A). Substituting these expressions in equations (24) and (25) allow us to rewrite the expressions of the output of a deviant firm from sector 1 and 2 as a function of parameters. For the specialized configuration to be an equilibrium this output must be smaller than the necessary level to break-even (q_1^*, q_2^*). So the total concentration of sector 1 in Home country and sector 2 in Foreign country is an equilibrium if and only if

$$\frac{\tilde{q}_1}{q_1^*} = \left(\frac{\alpha_2}{\alpha_1}\right)^{-\sigma\alpha_1(1-\gamma_1)} \tau^{1-\sigma(1+\gamma_1)}\left[1+\frac{1-\gamma_1}{2}(\tau^{2(\sigma-1)}-1)\right] < 1 \tag{30}$$

$$\frac{q_2}{q_2^*} = \left(\frac{\alpha_1}{\alpha_2}\right)^{-\sigma\alpha_2(1-\gamma_2)} \tau^{1-\sigma(1+\gamma_2)}\left[1+\frac{1-\gamma_2}{2}(\tau^{2(\sigma-1)}-1)\right] < 1 \tag{31}$$

Even if the expressions (30) and (31) are not easily turned into a closed form solution, let us get some insight of the dependence of the existence of a specialized equilibrium on the degree of economic integration. In a second step we'll illustrate graphically the shape of $\tilde{q}_1/q_1^*$ and q_2/q_2^* against trade costs.

First as τ approaches 1, $\tilde{q}_1/q_1^*$ and q_2/q_2^* respectively tend to $\left(\alpha_2/\alpha_1\right)^{-\sigma\alpha_1(1-\gamma_1)}$, $\left(\alpha_1/\alpha_2\right)^{-\sigma\alpha_2(1-\gamma_2)}$. This means that as long as the sectors have the same intensity in immobile factor $(\alpha_1 = \alpha_2)$ the quantity produced by a deviant firm equals unity. This result is standard in NEG, if countries are similar; when trade is totally free there is no reason for sectors to concentrate. Note that this result is true as long as the sectors have the same intensity in immobile factor. Otherwise the quantity produced by a deviant firm could exceed unity in at least one of the sectors. This could be seen on Figure 1**.**

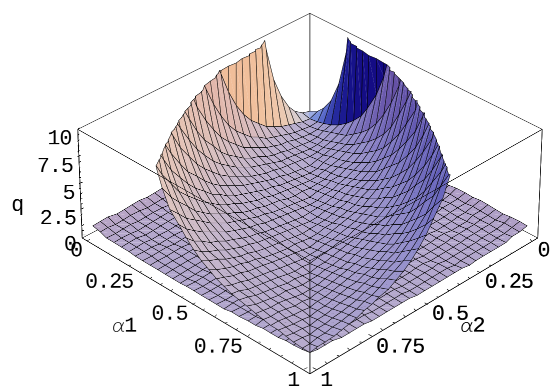

Fig. 1 — *Immobile factor intensity and incentive to deviate*.

The intuition given by Figure 1 is confirmed if we suppose for example that $\alpha_1 > \alpha_2$, then $W > \widetilde{W}$ (equations (A-1)) and the quantity produced by a deviant firm in sector 1 exceed unity. This result means that in the case of a total concentration, the price of the immobile factor is determined in each country by the intensity by which the firms use this factor. Then a difference in technology gives rise to a comparative advantage in terms of the price of the immobile factor. Note that this comparative advantage does not depend on an initial difference in endowments but results in the combination of activity location and technology.

In the vicinity of $\tau = 1$, $\partial\left(\tilde{q}_1 / q_1^*\right) / \partial\tau$ and $\partial\left(q_2 / q_2^*\right) / \partial\tau$ are negative. This implies that for sufficiently low trade costs there exists an equilibrium in which both sectors concentrate and so both countries are totally specialized.

Finally, taking the limit of expression (30) and (31) shows that as $\tau \to \infty$, so does the quantity produced by a potential deviant firm, so for large trade costs the sectors cannot concentrate.[6]

We turn now to a graphical analysis of the shape of $\tilde{q}_1 / q_1^*$ and q_2 / q_2^* as a function of trade costs, as drawn in Figure 2.[7]

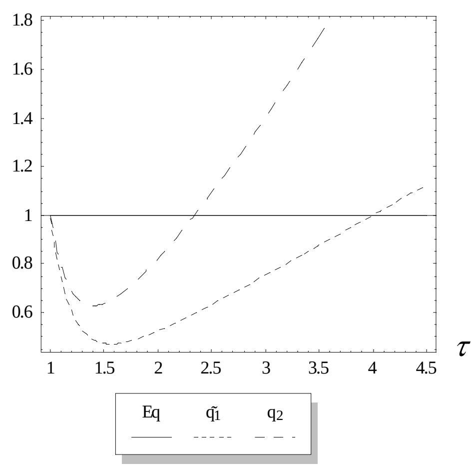

Fig. 2 — *Range of trade costs for which total concentration is sustainable*.

The graph confirms the first insight that the two industries cannot be concentrated and so the countries do not specialize under high trade costs. This result is consistent with standard trade and economic geography models; in autarky each county has to be self-sufficient and the industrial sectors activity is split between locations to serve the demand. Reducing trade costs from autarky to intermediate level can lead first to the complete concentration of sector 1 when the critical value $\tau_{s,1} \simeq 3.99$ is reached.

[6] This is true as long as the "No black hole conditions" holds. In the case of this paper this conditions is given by $\dfrac{\sigma - 1}{\sigma} > \gamma_s$. If this condition doesn't hold, the differentiation between varieties is such that trade cost doesn't influence demand, and in this case concentration forces are so strong that the complete concentration of sectors is always an equilibrium. See *Fujita, Krugman and Venables [1999]* for a detailed presentation of this condition.

[7] The set of parameters used is $\sigma = 4$; $\alpha_1 = 0{,}5$; $\alpha_2 = 0{,}5$; $\gamma_1 = 0{,}5$; $\gamma_2 = 0{,}4$.

Further reductions in trade costs can lead to the complete concentration of sector 2 (at $\tau_{s,2} \simeq 2.34$). The difference in the value of the sustain points is easily explained by the difference in the industrial linkages between firms in each sectors.

Finally, for free trade and in the case of an identical intensity in the use of immobile factor there are no more incentives to concentrate.

In the preceding development we saw that there exists a range of trade costs between the two critical values for which the sector 1 is fully concentrated, but it is not the case for sector 2. Due to the existence of this range of trade costs, two points need to be clarified: first, how the critical value for sector 1 is affected by the fact that sector 2 was not concentrated? Second, how sector 2 activity's is shared between the two countries when sector 1 is concentrated? We answer these two questions in the following paragraphs.

> **Proposition 2:** Taking into account that sector 2 was not concentrated will reduce the value of trade cost for which a full concentration of sector1 is possible. Indeed the demand for immobile factor emanating from firms in sector 2 on Home market raises the price of this factor and so reinforces centrifugal forces.

Taking into account the difference in the critical values for sector 1 and 2 complicates the sustain point analysis. Indeed for $\tau_{s,1} > \tau > \tau_{s,2}$, $\tilde{h}_2$ is no longer equal to 1 and thus we cannot only retain the preceding equations to analyze the sustainability of the complete concentration of sector 1. In fact, for this range of trade cost the resolution underlying figure 1 implies that the demand of immobile factor emanating from sector 2 in Home country was not taking into account. In order to take into account such a demand, we must use the full expressions for the price index, expenditure and nominal wage with the condition that $h_1 = 1$ but $h_2 > 0, \tilde{h}_2 > 0$. To close the model we use the fact that skilled workers in industry 2 move between countries until real wage in the two countries are equalized. This yields a system of equations (which is given in appendix B) that must be numerically solved for different values of trade costs.[8] Doing this we obtain a value for $\tau_{s,1}$ lower than in the preceding graph, now the critical value at which sector 1 could be concentrated is $\tau_{s,1} \simeq 2.71$ (the critical value for sector 2 remaining unchanged).

This result of a lowest value of trade cost at which the concentration of sector 1 is sustainable is plausible. It means that because of the demand of firms in sector 2 for unskilled workers in Home country, the wage of these workers and so the cost for firms

[8] For the whole paper the Mathematica codes are available on demand from the author. The parameters used are the same as given before.

are higher than in the preceding case. This rise in the cost of production pushes up the centrifugal forces and discourages the full concentration of firms in sector 1 until a sufficiently low value of trade costs is reached.

We now turn to the allocation of sector 2 in the range of trade costs $2.71 > \tau > 2.34$, for which we know that sector 1 is fully concentrated and sector 2 remain split between countries. Again in this incomplete specialization range we have $h_1 = 1,\ \tilde{h}_1 = 0$ and $h_2 > 0,\ \tilde{h}_2 > 0$. To assess the equilibrium repartition of sector 2 activities' we must compute the real wage earned by skilled workers in this sector in both countries, and note that only a distribution compatible with an equalization of these wages is an equilibrium. We report on Figure 3 the real wage gap[9] between the two countries as a function of h_2, for different values of trade costs in the range $2.71 > \tau > 2.3$.

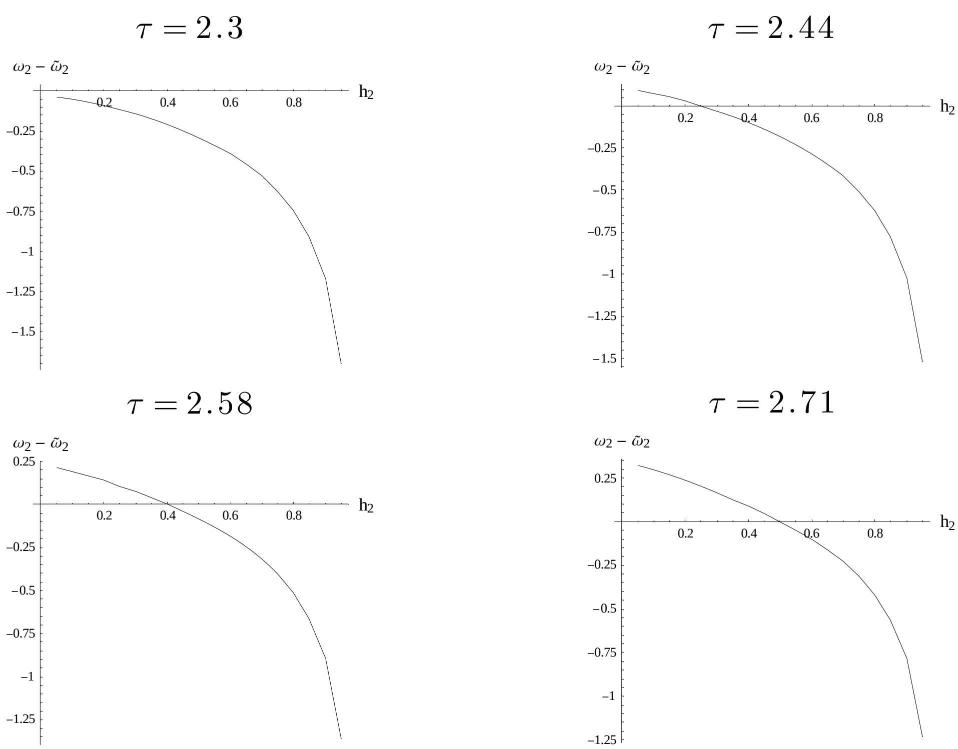

Fig. 3 — *Real wage differential in sector 2 in the case of complete concentration of sector 1*.

As we can see, the real wage gap of skilled workers in sector 2 compatible with a high share of this factor located in Home country is more likely the highest are the trade costs. Taking into account the fact that Home country already receives all the

[9] This gap is measured by $\omega_2 - \widetilde{\omega}_2$ where $\omega_2 = w_2 G_1^{\mu} G_2^{1-\mu}$ and $\widetilde{\omega}_2 = \widetilde{w}_2 \widetilde{G}_1^{\mu} \widetilde{G}_2^{1-\mu}$.

endowment of skilled workers of type 1, this result shows that the agglomeration is more likely the higher are the trade costs.

We can summarize the results reflected by the sustain point analysis:

If trade costs are high ($\tau > \tau_{s,1}$) it is costly to supply the distant country and firms in both sectors split between both countries.

For very low values of trade costs ($\tau \rightarrow 1$), as usual, there is no more incentive for firms to concentrate.[10]

For intermediate values of trade costs ($\tau_{s,2} > \tau$) firms can supply all markets at low cost and because of vertical linkages they have incentives to concentrate in one location (one sector by country). Countries will specialize.

Furthermore there exists a range of trade costs ($\tau_{s,1} > \tau > \tau_{s,2}$) in which sector 1 concentrates in Home country while activity of sector 2 remains spread between locations. In this range, as trade costs are reduced, the sector 2 leaves gradually the Home country and concentrates in Foreign country, leading to the specialized situation previously described.

Interpreted in terms of agglomeration this result gives the usual *U-shape* relation between agglomeration and integration. When trade costs are high the two sectors split. A reduction of trade costs leads to the concentration of sector 1 while sector 2 is still split between countries. This stage corresponds to the agglomeration of economic activity in the Home country ($AGG = h_1 + h_2$ with $h_1 = 1$ and $h_2 > 0$). Further reduction in trade costs allows sector 2 to concentrate in Foreign. Note that during this integration process and unlike standards results in NEG literature if a deeper integration allows a convergence process in term of size of the countries this doesn't means a convergence in terms of the productive structure of these countries. Here countries ended in a totally specialized configuration. Beyond the sole interest in terms of activity spatial allocation this result gives rise to questions in terms of policy choice in an integrated zone, for example to manage asymmetric chocks affecting a particular sector.

3.2 Stability of a Dispersed Equilibrium

In this sub-section we take as a starting point a symmetric allocation of the activity. This point is defined as a situation in which the skilled workers of each type, and so the sector which uses it, are evenly split between the two countries. We are interested in the

[10] This is true as long as the intensity in immobile factor are the same in both sectors

way such a situation could be affected by a trade costs reduction. As usual in NEG literature this means that we are looking for the critical values of trade cost at which this symmetric equilibrium becomes unstable.

> **Proposition** 3: The asymmetry in industrial linkages induces a higher value of trade cost for which the symmetric equilibrium is broken in sector 1 than in sector 2. Furthermore, due to the use of an immobile factor in the industrial production, there will be two critical points for each sector. This result means that a dispersed situation is stable for high values of trade cost (because of demand considerations) and for low values of trade cost (because of production cost considerations)

To determine these critical values we must study how a relocation of skilled workers between locations will affect theirs real wage for different values of trade costs. If labor inflow increases relative wage in the receiving country, then the initial configuration was not a stable equilibrium. Conversely, if relative wage change in favor of the location from which labor has migrated, then the initial equilibrium is stable.

Remember that the migration of skilled workers is driven by real wage gap between countries. Since we are interested in the way a reallocation of skilled workers affects the real wage of skilled workers, let us linearise the system of differential equations defined by price indexes, expenditure, nominal and real wages of skilled and unskilled workers in the neighborhood of the symmetric equilibrium which is formally defined as a situation in which the share of mobile factor is such as $h_1 = \tilde{h}_1 = h_2 = \tilde{h}_2 = 1/2$, a change in a variable in a location is always associated with a change, of opposite sign but of equal absolute magnitude, in the corresponding variable in the other location $dh_s = -d\tilde{h}_s$, and then study the sign of $d\omega_s / dh_s$ where $\omega_s = w_s G_1^{-\mu_1} G_1^{-\mu_2}$.

The first step to solve the problem is to take into account that thanks to the symmetry of the model, around the symmetric equilibrium, each endogenous variable in both countries has an identical value. For example the price index of sector 1 in Home country is identical to the price index of this sector in Foreign country, this gives $G_1 = \widetilde{G}_1$, what we note G_1^*. The same notations hold for all variables and we can rewrite all the endogenous variables in the symmetric configuration. This gives for the price index, the industrial expenditure, the skilled and unskilled wage

$$
\begin{aligned}
\left(G_1^*\right)^{1-\sigma(1-\gamma_1)} &= \frac{\left(W^*\right)^{-\sigma\alpha_1(1-\gamma_1)}\left(w_1^*\right)^{1-\sigma(1-\alpha_1)(1-\gamma_1)}\left(1+\tau^{1-\sigma}\right)}{2\left(1-\alpha_1\right)\left(1-\gamma_1\right)} \\
\left(G_2^*\right)^{1-\sigma(1-\gamma_2)} &= \frac{\left(W^*\right)^{-\sigma\alpha_2(1-\gamma_2)}\left(w_2^*\right)^{1-\sigma(1-\alpha_2)(1-\gamma_2)}\left(1+\tau^{1-\sigma}\right)}{2\left(1-\alpha_2\right)\left(1-\gamma_2\right)}
\end{aligned}
\tag{32}
$$

$$E_1^* = \frac{1}{2}\left[W^* + \frac{w_2^*}{2} + w_1^* \frac{1-\alpha_1+\gamma_1+\alpha_1\gamma_1}{2(1-\alpha_1)(1-\gamma_1)}\right]$$
$$E_2^* = \frac{1}{2}\left[W^* + \frac{w_1^*}{2} + w_2^* \frac{1-\alpha_2+\gamma_2+\alpha_2\gamma_2}{2(1-\alpha_2)(1-\gamma_2)}\right] \tag{33}$$

$$\left(w_1^*\right)^{\sigma(1-\alpha_1)(1-\gamma_1)} = \left(W^*\right)^{-\sigma\alpha_1(1-\gamma_1)} E_1^* \left(G_1^*\right)^{\sigma-1-\sigma\gamma_1}\left(1+\tau^{1-\sigma}\right)$$
$$\left(w_2^*\right)^{\sigma(1-\alpha_2)(1-\gamma_2)} = \left(W^*\right)^{-\sigma\alpha_2(1-\gamma_2)} E_2^* \left(G_2^*\right)^{\sigma-1-\sigma\gamma_2}\left(1+\tau^{1-\sigma}\right) \tag{34}$$

$$W^* = \frac{\alpha_1}{2\left(1-\alpha_1\right)} w_1^* + \frac{\alpha_2}{2\left(1-\alpha_2\right)} w_2^* \tag{35}$$

The system of equations (32)-(35) could be solved, and for the perfectly dispersed equilibrium we found taking the unskilled wage as a numeraire

$$w_1^* = \frac{2\left(1-\alpha_1\right)}{\alpha_1+\alpha_2}$$
$$w_2^* = \frac{2\left(1-\alpha_2\right)}{\alpha_1+\alpha_2}$$
$$W^* = 1$$

Total differentiation around the symmetric equilibrium yields nine equations of interest (see appendix C) and it is necessary to solve this system in order to obtain the expressions $d\omega_s/dh_s$ for which we are interested in the sign. To solve the system we have to remember that a specificity of our model is that we have two state variables, the mobile skilled labor used in each sector, which increase the complexity of the perfectly dispersed equilibrium. To make the resolution tractable we refer to the two assumptions $dh_2^*/dh_1^* = d\omega_2^*/dh_1^*$ and $dh_1^*/dh_2^* = d\omega_1^*/dh_2^*$ which means that a variation of labor in a given industry affect labor in the other industry through the variation induced in the real wage of this latter industry with a unit coefficient. If this assumption is similar to usual *ad hoc* migration dynamics assumptions made in NEG models the particular form it takes here is borrowed from *Coulibaly [2004]*.

We are now ready to determine the value of trade cost at which the initial symmetric equilibrium ceases to be stable. The complexity of the model doesn't allow us to obtain a tractable analytical solution for this problem, so we resort to a graphical exploration in Figure 4. Here a positive value of the expression $d\omega_s/dh_s$ suggests that labor reallocation is followed by a higher gain in terms of real wage, hence the breaking of the perfectly dispersed equilibrium. A negative value indicates that labor reallocation implies a loss in terms of real wage, hence the stability of the perfectly dispersed equilibrium.

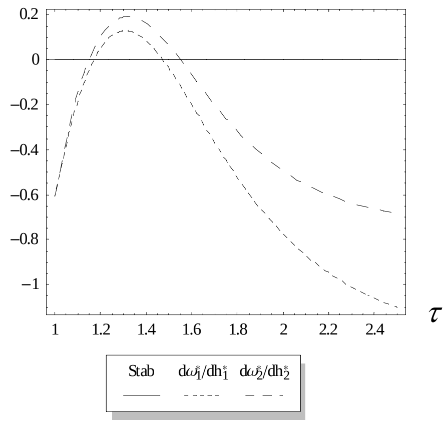

Fig. 4 — *Range of trade costs for which symmetric equilibrium is stable*.

The graph indicates that when trade costs are very high, the two industries split evenly between the two locations to supply local consumers at low cost. Dispersion forces are stronger than concentration forces. As trade costs decrease we reach a first break point ($\overline{\tau}_{B,1} \simeq 1.64$) at which the sector 1, which has the stronger intra-industry linkages, can deviate from the symmetric equilibrium to exploit concentration externalities. The symmetric equilibrium breaks in sector 2 at a lower trade costs level ($\overline{\tau}_{B,2} \simeq 1.45$). As before the difference in the two critical values is well explained by the differences in industrial linkages intensity.

As trade costs keep on decreasing, we reach a reverse break point, first in sector 2 and then in sector 1 (respectively $\underline{\tau}_{B,2} \simeq 1.17$ and $\underline{\tau}_{B,1} \simeq 1.14$). This reverse break point means that at very low levels of trade costs the dispersed equilibrium is again a possible outcome. To understand the occurrence of this reversal, remember that the forward and backward linkages between firms disappear when trade cost goes to 1 (free trade). So in the vicinity of free trade there is no more incentives to concentrate, this is true in all models in the literature. But here at the same time because of the competition on the immobile factor market, there are incentives acting against the concentration. Indeed a deviation will raise the price of the immobile factor and then the production cost. Close to free trade centrifugal forces are no longer compensated by centripetal forces. This is why here the reversal point occurs for sufficiently low but positives values of trade costs instead of for $\tau = 1$ as usually in the literature. This result could be compared to the one exposed by *Fujita, et al. [1999] chap. 14* in the case of decreasing returns in traditional sector. But an important difference must be noted. The symmetric equilibrium is not unique and coexists with a concentrated situation (see *supra*). The second contribution exhibiting the same result is the one from *Forslid and Wooton [2003]*, in which the reversal point is due to an initial comparative advantage due to difference in productions costs.[11] Here, what can be interpreted as a comparative advantage does not belong to an initial advantage but is endogenous and depends on the combination of industry location and technology.

Before going further let us summarize what we have learned from the break point analysis: for intermediate value of trade costs, in each sector, there are incentives to deviate from the symmetric equilibrium to exploit concentration externalities induced by input-output linkages. On the contrary, for high or low values of trade cost, the symmetric allocation is a stable equilibrium. Note that the causes of this stability are different. For high values of trade costs the symmetric equilibrium is due to the need to serve demand in each country. For low trade costs the symmetry is induced by production cost considerations, particularly the price of immobile workers. Finally there is a range of trade costs for which sector 1 deviation is possible but not for sector 2 involving a possible partial agglomeration.[12]

To go a step further, and as we did for the break point analysis, we pay attention to the dependence of the stability of the symmetric equilibrium to a change in the immobile factor intensity. To do so we compute for different value of α_s the range of trade cost for which the symmetric equilibrium is not stable, this mean that we compute the difference between $\overline{\tau}_{B,s}$ and $\underline{\tau}_{B,s}$. The results are reported on Figure 5.

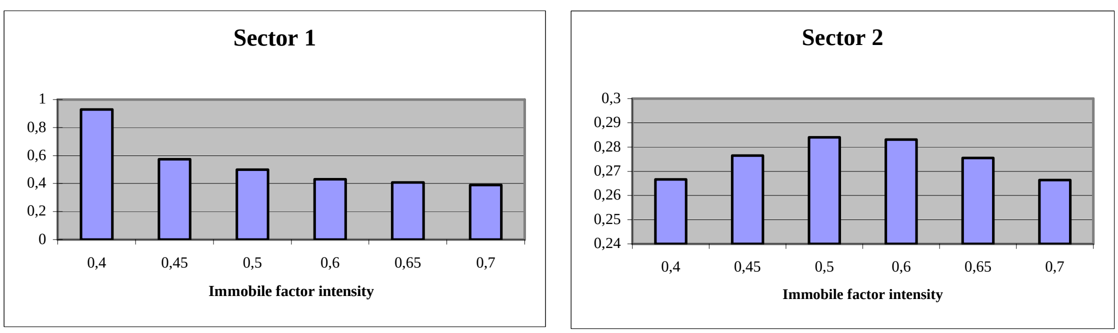

Fig. 5 — *Symmetric equilibrium instability and immobile factor intensity*.

Many points have to be clarified: First as expected, independently of immobile factor intensity, the sector 1 in which intra-industrial linkages are the strongest, exhibits a stronger propensity to deviate from the symmetric equilibrium. Second there is a monotonic decreasing relation between the intensity in immobile factor and the tendency to deviate in this sector while this relation is non-monotonic in sector 2. The

[11] *Tabuchi [1998]* develop a model in which the stability of the symmetric equilibrium for low value of trade cost rely on the existence of urban costs.

[12] Unfortunately due to computation limitations it is impossible to give more details on the evolution of the location of sector 1 in this case.

relation for sector 1 is not surprising, since the role of factor immobility is well established in the literature.[13] On the other hand the non-monotonic relation in sector 2 is an original result and needs to be explained.

Moving from a low value of intensity in the immobile factor ***(0.4)*** to an intermediate one ***(0.45; 0.5)***, induces an expected decrease of the range of stability for sector 1 but an increase for sector 2. This increase means that the centripetal forces have gained in intensity. These forces are partly due to the industrial linkages between firms which are well established in the literature and partly due to an effect on the immobile factor market. This last effect comes from the fact that sector 1 deviates first (for higher value of trade costs). Then, the concentration of this sector produces, by a competition effect, a rise in the price of the immobile factor in the country in which the concentration takes place. This rise encourages firms from sector 2 to deviate. More than to deviate, it encourages firms from sector 2 to choose the other country than the country receiving sector 1. We can interpret this relation between the two sectors as a pecuniary externality which is mediatized by the immobile factor market. This externality could be understood as a negative externality because it pushes against the co-location of sectors. On the other hand, it could be understood as a positive externality because it pushes firms in sector 2 to concentrate and so country to specialize. This externality favors the concentration of sectors and determines the country in which sector 2 will concentrate. Note that the strength of this externality reaches a peak for intermediate value of α_s, after which the relation between an increase in the immobile factor intensity and the propensity to deviate find its normal shape. Now both sectors are so intensive in the immobile factor that sufficiently low values of trade cost are needed to permit a deviation from the symmetric equilibrium. Finally a change of the intensity with which the sectors use the immobile factor sheds light on the role of competition on this market on the spatial allocation of activities through the reciprocal influence that each sector exerts on the other.

3.3 From Dispersion to Re-dispersion: The Role of Demand and Cost of Production in Location Choices

Until now we studied the evolution of the economic activity location taking specific initial repartitions as a departure point. We wish now to consider the equilibrium allocation of the activity without assuming any initial repartition.

> **Proposition 4**: Because of the absence of an immobile sector offering an alternate activity to immobile workers, in our model if the symmetric configuration is not initially specified, the activity will agglomerate even for

[13] For example many papers evoke the lack of migration in Europe to explain the smaller levels of concentration compared to the US (*Krugman [1991a]*, *Puga [2002]*).

very high level of trade cost. Moreover, if integration leads to a reallocation of the activities, two main stages must be distinguished. A first one in which both sector will relocate from the core to the periphery (dispersion) and a second one in which only one sector will relocate (re-dispersion) inducing county specialization.

Abstracting from any initial repartition of mobile factors requires solving the whole model taking the share of both skilled workers in both countries as an unknown, which need again to resort to numerical simulations. We report on Figure 6 the evolution of the variable *AGG* for an extended range of trade costs.

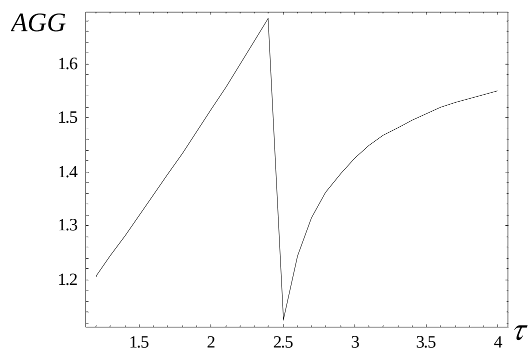

Fig. 6 — *Integration and agglomeration: two stages*.

The shape illustrated on this figure is unusual, with an agglomeration for very high level of trade cost, a dispersion of the activity until reaching a critical value of trade costs ($\tau \simeq 2.5$) after which we observe a usual *U-shape* relation between integration and agglomeration. Before carrying out the analysis of this shape, it is necessary to note that we do not pretend it illustrates a "real" evolution of the repartition of the activity. The goal of this presentation is to deepen our understanding of the different forces shaping the spatial distribution of activity.

To understand the forces at stake, let us divide the preceding integration process into two parts. The first one goes from high trade costs to the intermediate value $\tau \simeq 2.5$. The second one goes from this last value to free trade.

In the first stage of the integration process, for very high trade costs the two sectors have an incentive to concentrate and to co-locate, the aggregate activity is agglomerated. We know that monopolistic competition firms do better in a large market, here the countries are (practically) in autarky so there is an incentive to agglomerate and so to *create* a big market. This result requires, let us recall, that we abstract from the traditional sector. In the case of our model there is nothing to induce a symmetric repartition of activity, if this situation is not taken as an initial departure point, so when both sectors are free to choose their location a core-periphery pattern emerges inducing a high level of demand and a high level of production cost in the Core. Due to this high level of production cost, it is easy to understand that reducing trade costs encourages firms from both sectors to relocate. During this first stage of integration it is important to note that high intra-industrial linkages sector (sector 1) exhibit a lower concentration level than the low intra-industrial linkage sector (sector 2), as illustrated on Figure 7.

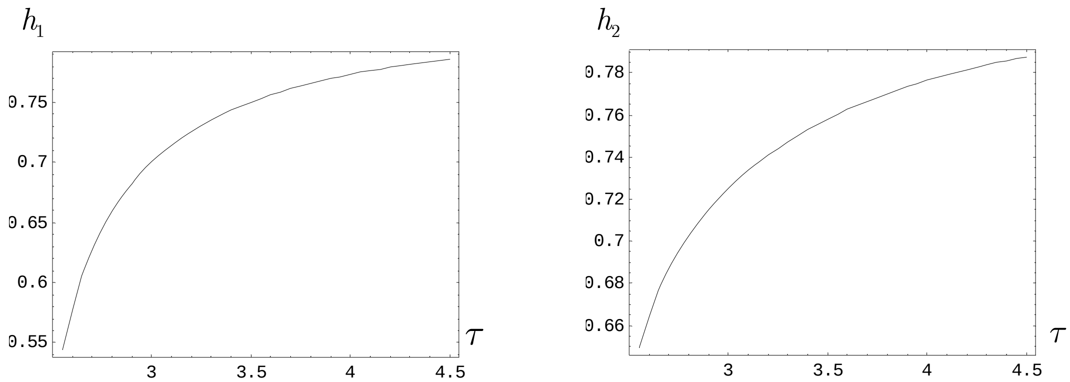

Fig. 7 — *Domestic share of both types of skilled workers*.

This result is somewhat surprising. In the NEG literature the level of concentration generally varies positively with the strength of industrial linkages. In there relocation process firms take account of cost and demand considerations. A relocation of firms from both sectors means a shift of demand between countries. Due to the input-output structure this shift is bigger (lower) when a firm from sector 1 (sector 2) relocates. To say it differently, because firms in sector 1 are strongly tied, when this sector needs to leave the core because of the cost of production, this sector is more independent of the rest of the economy. In some respect it is possible to establish a parallel between this result and *Puga and Venables [1996]*. Even if their model is built on a different framework, the authors show that when relocation is due to a change in an exogenous variable one must take the links of the sector with the rest of the economy into account in order to anticipate which sector will first leave the Core country.

The preceding result as well as those of *Puga and Venables* indicate that when relocation is due to factor cost differential, the input output linkages allow a sector to exploit earlier, in the sense of a higher value of trade cost, the advantage of a relocation in the (low cost) periphery.

Reaching the critical value, the agglomeration level follows the usual *U-shape* and the forces underlying this result are typical in NEG and could easily have been guessed from the study of sustain and break point. However, it is important to note that although deeper integration leads to a decline in agglomeration, this aggregate evolution came from a concentration process of individual sectors leading to the specialization of countries (Figure 8).

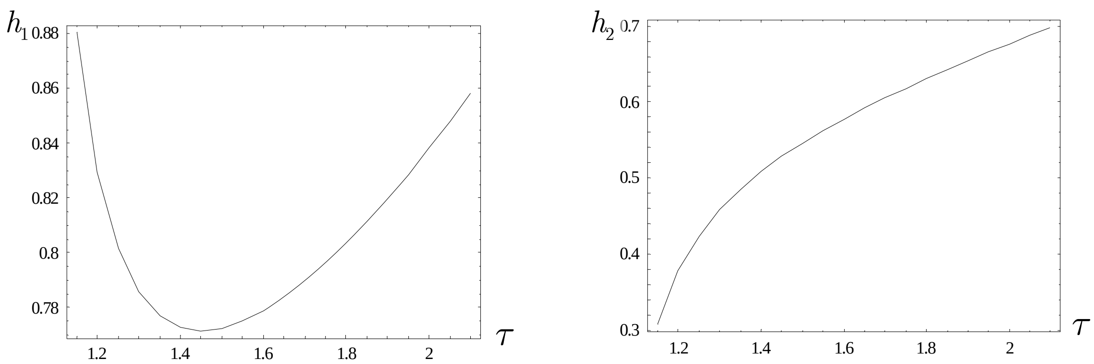

Fig. 8 — *Domestic share of both types of skilled workers*.

This indicates that when trade costs are low enough, the intermediate demand and cost of production considerations surpass the consideration for final demand. This reversal in the determinants of location is due to lower trade costs that allow supplying both markets from one location.

Studying the evolution of spatial location in the case of a unrestrained integration, one can distinguish forces pushing to a dispersion (the first stage) in which both sectors relocate from the core to the periphery from a re-dispersion process (the second stage) in which even if the location of both sector evolves, only one relocates from the core to the periphery. We come up with this result using a very simple model of NEG, similar to *Dao-Zhi [2006]* using a more complex model.

CONCLUSION

We have tracked locational equilibria in an economy consisting of two distinct countries, using a NEG model with two industries tied by intra-industrial linkages, two industry-specific internationally mobile production factors and an immobile generic factor of production. We found that, at early stages of integration, industries tend to evenly split between locations so that sectors co-locate within each location with no specialization. When trade costs fall to an intermediate level, a core-periphery distinction emerges among the two locations: the strong linkages industry partially then totally clusters in one location (the core) which also receives weak-linkages industry firms. As trade costs keep on decreasing, the weak-linkages firms located in the Home country relocate to the periphery until full concentration. Finally, once trade costs have fallen sufficiently, locations completely specialize, and industries no longer co-locate. However, at those advanced levels of integration, the peripheral region captures back activity from the core, so that the overall degree of agglomeration is reduced. If the threshold values of trade costs, as well as the uniqueness or multiplicity of equilibriums depend on parameter choice of the model, the qualitative evolution of the activity allocation remained unchanged. Note in particular that if the result of country industrial specialization is consistent with the results of *Krugman and Venables [1996]*, the model provides a richer insight into the evolution of industries location choices which are consistent with studies on the consequences of European integration (*Amiti [1998*;*1999]*, *Brülhart [1996];Brülhart [1998b]*, *Midelfart - Knarvik, et al. [2000]*).

Finally, most studies in the field have examined how the location of the all activity evolves during an integration process. This paper adds to this by introducing details on how the location of individual sectors location evolves. One of the main results of the model is that location choice must be understood at the industry level and not only at an aggregate one.

Appendix A — Concentration

Factor rewards

$$\begin{aligned} W &= \frac{\alpha_1}{\alpha_2}; \qquad \widetilde{W} = 1 \\ w_1 &= \frac{1-\alpha_1}{\alpha_1}; \quad \widetilde{w}_2 = \frac{1-\alpha_2}{\alpha_2} \end{aligned} \tag{A-1}$$

Taking the unskilled wage in Foreign country as a numeraire

Relative demand

$$\begin{aligned} \frac{E_1}{E_1+\widetilde{E}_1} &= \frac{1+\gamma_1}{2}; \\ \frac{\widetilde{E}_2}{E_2+\widetilde{E}_2} &= \frac{1+\gamma_2}{2}; \end{aligned} \tag{A-2}$$

$$\begin{aligned} \frac{\widetilde{E}_1}{E_1+\widetilde{E}_1} &= \frac{1-\gamma_1}{2}; \\ \frac{E_2}{E_2+\widetilde{E}_2} &= \frac{1-\gamma_2}{2}; \end{aligned} \tag{A-3}$$

Appendix B — System of equation in the case on concentration of sector 1, while sector 2 spread between countries

Price indexes

$$
\begin{aligned}
G_1 &= \left[n_1 p_1^{1-\sigma}\right]^{1/(1-\sigma)} \\
G_2 &= \left[n_2 p_2^{(1-\sigma)} + \tilde{n}_2 \left(\tilde{p}_2 \tau\right)^{1-\sigma}\right]^{1/(1-\sigma)} \\
\widetilde{G}_1 &= \left[n_1 \left(p_1 \tau\right)^{1-\sigma}\right]^{1/(1-\sigma)} = \tau G_1 \\
\widetilde{G}_2 &= \left[n_2 p_2^{(1-\sigma)} + \tilde{n}_2 \tilde{p}_2^{1-\sigma}\right]^{1/(1-\sigma)}
\end{aligned}
\qquad \text{(B-1)}
$$

Industrial demands

$$
\begin{aligned}
E_1 &= \left(1/2\right)\left(wL + r_1 K_1 + r_2 K_2\right) + \gamma n_1 p_1 \\
E_2 &= \left(1/2\right)\left(wL + r_1 K_1 + r_2 K_2\right) + \delta n_2 p_2 \\
\widetilde{E}_1 &= \left(1/2\right)\left(\tilde{w}\widetilde{L} + \tilde{r}_2 K_2\right) \\
\widetilde{E}_2 &= \left(1/2\right)\left(\tilde{w}\widetilde{L} + \tilde{r}_2 K_2\right) + \delta \tilde{n}_2 \tilde{p}_2
\end{aligned}
\qquad \text{(B-2)}
$$

Factor markets

$$
\begin{aligned}
& wL = \alpha\left(1-\gamma\right) n_1 p_1 + \beta(1-\delta) n_2 p_2 \\
& \widetilde{w}\widetilde{L} = \beta(1-\delta)\widetilde{n}_2 \widetilde{p}_2 \\
& r_1 \kappa_1 = (1-\alpha)\left(1-\gamma\right) n_1 p_1 \\
& r_2 \kappa_2 = (1-\beta)\left(1-\delta\right) n_2 p_2 \\
& \tilde{r}_2 \widetilde{\kappa}_2 = (1-\beta)\left(1-\delta\right)\widetilde{n}_2 \widetilde{p}_2
\end{aligned}
\qquad \text{(B-3)}
$$

Demand

$$
\begin{aligned}
q_1 &= \left(p_1\right)^{-\sigma}\left[E_1 G_1^{(\sigma-1)} + \widetilde{E}_1 \widetilde{G}_1^{(\sigma-1)} \tau^{(1-\sigma)}\right] = \frac{E_1 + \widetilde{E}_1}{n_1 p_1} = 1; \\
q_2 &= \left(p_2\right)^{-\sigma}\left[E_2 G_2^{(\sigma-1)} + \widetilde{E}_2 \widetilde{G}_2^{(\sigma-1)} \tau^{(1-\sigma)}\right] = 1 \\
\tilde{q}_2 &= \left(\tilde{p}_2\right)^{-\sigma}\left[E_2 G_2^{(\sigma-1)} \tau^{(1-\sigma)} + \widetilde{E}_2 \widetilde{G}_2^{(\sigma-1)}\right] = 1
\end{aligned}
\qquad \text{(B-4)}
$$

Real wages

$$r_2 G_2^{-1/2} G_2^{-1/2} - \tilde{r}_2 \widetilde{G}_2^{-1/2} \widetilde{G}_2^{-1/2} = 0 \tag{B-5}$$

With prices given by

$$\begin{aligned} p_1 &= \left[\omega^{\alpha(1-\gamma)} r_1^{(1-\alpha)(1-\gamma)} G_1^{\gamma}\right] \\ p_2 &= \left[\omega^{\beta(1-\delta)} r_2^{(1-\beta)(1-\delta)} G_2^{\delta}\right] \\ \tilde{p}_2 &= \left[\widetilde{\omega}^{\beta(1-\delta)} \tilde{r}_2^{(1-\beta)(1-\delta)} \widetilde{G}_2^{\delta}\right] \end{aligned} \tag{B-6}$$

Appendix C — Symmetry breaking: system of differential equations

$$\left[1-\sigma+\sigma\gamma_1 Z\right]\frac{dG_1^*}{G_1^*}=Z\left[2dh_1^*-\sigma\alpha_1(1-\gamma_1)\frac{dW^*}{W^*}+\left(1-\sigma(1-\alpha_1)(1-\gamma_1)\right)\frac{dw_1^*}{w_1^*}\right]$$
$$\left[1-\sigma+\sigma\gamma_2 Z\right]\frac{dG_2^*}{G_2^*}=Z\left[2dh_2^*-\sigma\alpha_2(1-\gamma_2)\frac{dW^*}{W^*}+\left(1-\sigma(1-\alpha_2)(1-\gamma_2)\right)\frac{dw_2^*}{w_2^*}\right] \quad \text{(C-1)}$$

$$\frac{dw_1^*}{w_1^*}=\frac{1}{\sigma(1-\alpha_1)(1-\gamma_1)}\left[-\sigma\alpha_1(1-\gamma_1)\frac{dW^*}{W^*}+Z\frac{dE_1^*}{E_1^*}+(\sigma-1-\sigma\gamma_1)Z\frac{dG_1^*}{G_1^*}\right]$$
$$\frac{dw_2^*}{w_2^*}=\frac{1}{\sigma(1-\alpha_2)(1-\gamma_2)}\left[-\sigma\alpha_2(1-\gamma_2)\frac{dW^*}{W^*}+Z\frac{dE_2^*}{E_2^*}+(\sigma-1-\sigma\gamma_2)Z\frac{dG_2^*}{G_2^*}\right] \quad \text{(C-2)}$$

$$2dE_1^*=dW^*+\left[\frac{(1+\gamma_1-\alpha_1+\alpha_1\gamma_1)}{2(1-\alpha_1)(1-\gamma_1)}\right]dw_1^*+\left[\frac{w_1^*(1+\gamma_1-\alpha_1+\alpha_1\gamma_1)}{(1-\alpha_1)(1-\gamma_1)}\right]dh_1^*+\frac{dw_2^*}{2}+w_2^*dh_2^*$$
$$2dE_2^*=dW^*+\left[\frac{(1+\gamma_2-\alpha_2+\alpha_2\gamma_2)}{2(1-\alpha_2)(1-\gamma_2)}\right]dw_2^*+\left[\frac{w_2^*(1+\gamma_2-\alpha_2+\alpha_2\gamma_2)}{(1-\alpha_2)(1-\gamma_2)}\right]dh_2^*+\frac{dw_1^*}{2}+w_1^*dh_1^*$$
(C-3)

$$dW^*=\frac{\alpha_1}{(1-\alpha_1)}\left(\frac{dw_1^*}{2}+w_1^*dh_1^*\right)+\frac{\alpha_2}{(1-\alpha_2)}\left(\frac{dw_2^*}{2}+w_2^*dh_2^*\right) \quad \text{(C-4)}$$

$$\frac{d\rho_1^*}{\rho_1^*}=\frac{dw_1^*}{w_1^*}-\frac{1}{2}w_1^*\left(\frac{dG_1^*}{G_1^*}+\frac{dG_2^*}{G_2^*}\right)$$
$$\frac{d\rho_2^*}{\rho_2^*}=\frac{dw_2^*}{w_2^*}-\frac{1}{2}w_1^*\left(\frac{dG_1^*}{G_1^*}+\frac{dG_2^*}{G_2^*}\right) \quad \text{(C-5)}$$

Avec $Z\equiv\frac{(1-\tau^{1-\sigma})}{(1+\tau^{1-\sigma})}$

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