Coordination costs and the redispersion of industrial activities

Sandrine Noblet

University of Corsica, CNRS UMR LISA 6240 - Campus Caraman BP 52 - 20250 Corte (FRANCE) (email: noblet@univ-corse.fr)

Abstract

The incompleteness of contracts in distant input-output linkages has been emphasized in the New New Trade Theory (Grossman and Helpman (2004)). Following this argument, this paper introduces uncertainty in input-output linkages in a New Economic Geography framework. I argue that uncertainty involves coordination costs, which depend on: i) distance that prevents downstream firms to fully monitor their suppliers, and ii) the complexity of the production process. In a Venables (1996) framework, this paper shows that coordination costs add a new trade-off for downstream firms that favors agglomeration even in the latter stage of an integration process. More precisely, I derive analytically the value of coordination cost which prevents the redispersion of economic activities.

Key words: firms location decision, input-output linkages, uncertainty, coordination costs

JEL Classification: F12, F15, R12, O18

1 Introduction

An important issue in the New Economic Geography (NEG) literature is to assess the nature of the relationship between the level of transport costs and the degree of agglomeration: once the agglomeration of industrial activities has occurred, do industries tend to redisperse or not with the pursuit of the integration process? At a first glance, theoretical predictions differ in the polar models of Krugman (1991) on the one hand, and Krugman and Venables (1995), Venables (1996) on the other hand. Actually, those models share similar cumulative agglomeration mechanisms. The concentration of increasing return-to-scale industrial activities, which arises from labor mobility in the former model and from firms mobility, notably due to input-output linkages,
in the latter ones, increases wages in the core region. In Krugman (1991), the wage differential disappears as soon as all labor has migrated toward the core region. However, in Krugman and Venables (1995) and Venables (1996), the wage differential is likely to persist. Then, a continuous fall in transport cost does not alter the core-periphery (CP) equilibrium in the former model. However in the latter, as intermediate goods become cheaper to trade, wage differential, local competition effect and demand linkages with final consumers, lead to a redispersion process of industrial activities, in the latter stage of the integration process. In short, this so-called "Reverted U-shaped" convergence scenario relies on two keys assumptions: a weak labor mobility and strong input-output linkages.

As both weak labor mobility (Tassinopoulos and Werner (1999)) and strong input-output linkages are relevant for Europe (Amiti (1999), Haaland et al. (1999), Midelfart-Knarvik et al. (2002)), it could be argued that the European integration process should have induced the kind of U-shaped dynamics described above. The fact that massive redispersion of industrial activities in favor of peripheral regions is not observable in Europe, despite the high level of integration, is then puzzling for the NEG literature. Indeed, empirical studies have emphasized that if western European countries have converged, this phenomenon of convergence is observe between nations but not at the regional level (Combes and Overman (2004), Head and Mayer (2004), Geppert and Stephan (2008)). Moreover, convergence between nations is not synonym of a fall in manufacturing concentration. Indeed, a recent contribution by Brühlhart and Traeger (2005) highlights that if the manufacturing industry is less concentrated in terms of topographic concentration, it is more concentrated in terms of relative concentration.

Some arguments exist in the literature to solve this paradox. For instance, Puga (1999) and Faini (1999) emphasis institutional labor markets rigidities. Bellone and Maupertuis (2003) show that localized knowledge externalities impede the redispersion of industrial activities even in the presence of labor immobility and perfect wage flexibility.

This paper proposes another explanation which emphasizes uncertainty in distant input-output linkages and associated coordination costs. The idea that contracts between distant upstream and downstream firms are more risky because of their incomplete nature, has been recently emphasized in the “new” new trade literature (see in particular Grossman and Helpman (2004)). Moreover, the relevance of coordination costs in shaping trade patterns has been pointed out in the recent gravity literature. In this literature, the increasing importance of coordination costs may indeed help to solve an apparent paradox, namely that the sensitivity of trade flows to distance has increased over the last 25 years despite the continual decrease of transport costs (Disdier and Head (2008)). Finally, a recent study Dachs et al. (2006) on the Euro-
pean manufacturing industry highlights that the high level of coordination costs and communication costs in offshoring within Eastern European countries was a reason which has incited firms to relocate their production in the home countries. According to this study, one fifth of British firms and one seventh of French firms that offshored part of their activities have relocated their production in home country in 2003. Following this empirical finding, this paper argues that the presence of coordination costs in distant vertical linkages creates a fundamental asymmetry between trade in final goods and trade in intermediate goods. For intermediate goods, a delay in their deliveries holds up the production as the production can not be achieved without all components. Such delays can then induce highly damageable disorganization with additional costs occurring in cascade. Moreover geographical distance involves uncertainty about the exact characteristics of the intermediate goods which can also be very damaging if some unexpected characteristics are incompatible with other components in the production process. As far as final goods are concerned, a delay in delivery or some missing characteristics compared to the expected ones, will lower the consumer utility but will not in general have such disruptive consequences.

The central issue investigated is how the presence of coordination costs in distant output-input linkages changes the patterns of firms location. This issue is addressed within a two-regions model à la Venables (1996) in which I introduce a coordination cost in input-output relationship. I assume that the need of coordination between upstream and downstream industries has two main sources: i) first, the geographical distance between intermediate and final producers; ii) second, the complexity of the production process captured by the number of intermediate goods used in final production. The main finding is that the presence of this coordination cost can prevent redispersion from occurring for very low transport costs, despite wage differential between regions. In particular, I assess condition on coordination cost under which the relationship between the level of transport cost and the degree of agglomeration switches from a "Reverted U-Shaped" nature to a monotonic one. Above a critical value of coordination cost parameter, agglomeration stands and below it industrial activities are evenly split across regions.

Emphasizing the fundamental difference between trade of intermediate and final goods, my model is strongly reminiscent of Alonso-Villar (2005) who investigated in the Venables (1996) framework the impact of ad-hoc differences in transport costs between different types of goods. She showed that a fall in the transport costs of final goods, maintaining constant and high the level of transport costs of intermediate goods, was precluding any redispersion of industrial activities toward the Periphery. Compared to Alonso-Villar (2005), my paper goes one step further in the following respects: first, it offers an eco-

\footnote{Amiti (2004) also studied this issue but in a different framework.}
nomic rational to the existence of an asymmetry between interregional transfer costs of final and intermediate goods. Second, it shows how this asymmetry partly occurs as an endogenous response to the integration process, since the level of coordination cost depends on the number of intermediate goods.

The rest of the paper is organized as follows. The next section describes the consequence of uncertainty in vertical linkages, involving coordination cost in addition to transport costs in the trade of intermediate goods. Section 3 presents the model which extends the original framework of Venables (1996) with the coordination cost expressed in section 2. Section 4 investigates conditions under which a CP outcome is sustainable in this setting. Finally, some concluding remarks are presented in section 5.

2 Uncertainty in input-output linkages

This section gives a description of the linkages between upstream and downstream sectors characterized by uncertainty. Final goods are produced with labor and differentiated intermediate goods whereas the production of intermediate goods requires labor only.

When a downstream firm purchases an intermediate good to an upstream firm, it is expecting that the good will have some required characteristics, in a infinite intermediate goods space of specifications (Grossman and Helpman (2002)), that have been specified in the contract linking both firms. However, the very nature of such contracts is incomplete in the sense that downstream firms are never able to fully monitor their suppliers (Grossman and Helpman (2004)), and especially with respect to goods characteristics. Let $z$ represents the distance, in a specific metric, between the expected (optimal) characteristics and the real ones. This $z$ value is a random variable. Its density function is denoted $g(z)$, defined in $\mathbb{R}^+$. The gap between the expected set of characteristics and what the firm actually get, creates an additional cost in the production process. Indeed, the firm will need to adjust intermediate goods characteristics, the level of adjustment depending on $z$ value. Considering that $g(z)$ follows an exponential law with parameter $\gamma$, $g(z)$ is defined as follow:

$$g(z) = \gamma e^{-\gamma z}$$

The expected value of $z$ is given by: $E(z) = \frac{1}{\gamma}$. This equation shows that the higher is $\gamma$, the higher is the probability that the set of characteristics is close to the expected one. I assume that both geographical distance and complexity of production process, captured by the number of varieties ($n_I$),
influence the value of $\gamma$. Hence, $\gamma$ is more likely to be low with a large number of differentiated intermediate goods used in the production process and with geographical distance, which implies a higher need of coordination between upstream and downstream firms. Indeed, downstream firm needs to organize the assembly of a larger set of differentiated inputs and the more distant it is from its suppliers, the smaller is the probability that the set of characteristics is close to those expected. In short, distance introduces uncertainty about what downstream firms will finally get. This idea is formalized, considering that $\gamma$ is an inverse function of complexity $n_I$ and geographical distance $d$:

$$\gamma = \frac{1}{\phi d n_I}$$

(1)

$\phi > 0$ is a key parameter since it gives the sensitivity of the variable $\gamma$ to both determinants ($d$ and $n_I$). For a given distance and a given level of complexity, the larger is $\phi$, the bigger will be the negative impact on the probability that characteristics match with the expected ones. Moreover, equation (1) shows that the higher is the geographical distance between trade partners, and the higher is the number of varieties entering in the production process, the lower is the probability that characteristics will be close to the expected one.

Then, the consequences of a low value of $\gamma$ (high expected value of $z$) can all be evaluated in term of cost: the so-called coordination cost. For the sake of simplicity, I assume that the level of coordination costs is proportional to $z$. Let $c_O$ denote the coordination cost. Using the Samuelson formulation of iceberg-type costs, this cost will be introduced in the model (section 3) as multiplicative to the intermediate good price$^2$:

$$c_O = p_i \times z.$$  

where $p_i$ is the intermediate good price of a variety $i$, for $i \in [1, n_I]$. As $c_O$ is function of $z$, it is a random variable. The expected cost is then given by:

$$E(c_O) = \frac{p_i}{\gamma}$$

Reintroducing equation (1) into this equation yields: $E(c_O) = p_i \times \phi d n_I$.

Finally, the interregional transfer cost of intermediate good encompasses both the transport cost$^3$ and the coordination cost, such as:

$$\tau + \phi d n_I$$

(2)

I assume the downstream producers are risk-neutral. This specification of transfer costs for intermediate inputs has two implications that deserve some comments. First, it implies that only contractual relationships between distant suppliers and consumers involve the type of uncertainty that gives rise to co-

$^2$ An appropriate specification would contain a proportionality coefficient, such as $c_O = \psi p_i \times z$. However, I choose $\phi$ so as $\psi$ is normalized to unity.

$^3$ With $\tau > 1$. 

5
ordination costs. This assumption is made for the sake of simplicity. In reality, contracts between local upstream and downstream firms are also incomplete. However, the main point is that contracts between distant partners are far more risky than contracts between local ones Dixit (2003). The second interesting feature of this specification is that coordination costs increase with the number of intermediate goods used in production, which in a NEG framework, involves an endogenous evolution of this cost.

3 Coordination costs in a Venables (1996) framework

The basic structure of the Venables model is a two-regions setting. Regions 1 and 2 are endowed with the same amount of labor which is mobile across sectors, but immobile across regions. Three different sectors are potentially active in each region. First, a traditional sector, characterized by perfect competition, produces an homogeneous good under decreasing returns-to-scale. Second, two industrial vertically-linked sectors, characterized by imperfect competition à la Chamberlin, produce horizontally differentiated goods under increasing returns-to-scale. Traditional goods are tradeable without cost whereas trade in industrial goods (both intermediate and final goods) involves transport costs. Let \( \tau_{12} \) represent the exogenous transport cost parameter \(^4\) from region 1 to region 2 which is the same for both intermediate and final good. Moreover, trade of intermediate goods involves a coordination cost \( \phi n_{I} d \) presented in the previous section. As it has been assumed in the previous section, only interregional flows of intermediate goods bear coordination cost. I pose \( d = 1 \) for distant purchase and \( d = 0 \) for local one. In order to keep a concordance between notations of final goods transfer cost and intermediate goods ones, interregional transfer cost for final goods is simply equal to \( \tau \), and interregional transfer cost for intermediate goods is equal to \( (\tau + \phi n_{I}) \).

The introduction of coordination costs modifies the equilibrium and thus change firms localization patterns. Indeed, uncertainty in distant vertical linkages adds a new trade-off in the decision of localization for downstream firms. This section describes first how the presence of coordination costs changes the profit equation in the downstream sector. Then, I present how these changes impact firms decisions in the two others sectors, respectively the upstream industrial sector and the agricultural one. Finally, the consumer behavior is presented.

\(^4\) It is assumed that \( \tau_{12} = \tau_{21} \), so from here subscripts will be dropped.
3.1 Downstream sector

The downstream sector in region $k$, for $k \in \{1, 2\}$, is composed of $n_{Fk}$ firms, each of them producing a different variety $j$ of final goods, for $j \in [1, n_{Fk}]$. The production of any variety $j$ requires the combination of labor and an intermediate goods composite, represented by a Constant-Elasticity-of-Substitution (CES) function\footnote{This technology ensures that downstream firms use as much different varieties of intermediate goods as available.}. The production function of a representative downstream firm takes the following form:

$$AL^{1-\mu}X^{\mu}_{Ik} = f + x_{jk}, \quad \forall k \in \{1, 2\}$$

where $L_{Ik}$ and $X_{Ik}$ are respectively the quantity of labor and of intermediate goods composite required to produce a quantity $x_{jk}$ of the variety $j$ in region $k$. $\mu$ and $(1-\mu)$ account respectively for the share of intermediate input and labor used in production. A quantity $f$ of the gross production is a sunk cost and $x_{jk}$ is the net production. $A$ is a scale parameter normalized such $A = \mu - \mu (1-\mu)^{\mu-1}$. Finally, the intermediate input $X_{Ik}$, defined as a CES composite of intermediate goods, can be written as:

$$X_{Ik} = \left(\sum_{i=1}^{n_{Ik}} x_{ikk}^{\frac{1}{\sigma}} + \sum_{i=1}^{n_{Ik}'} x_{ik'k}^{\frac{1}{\sigma}}\right)^{\frac{\sigma}{1-\sigma}}, \quad \forall k \in \{1, 2\}$$

Notice that $x_{ikk}$ are the quantities of intermediate good produced and locally supplied and $x_{ik'k}$ are the quantities produced in $k$ and shipped to distant market $k'$. $\sigma$ denotes the elasticity of substitution between two different varieties $i$. The factor demand functions, derived from the cost minimization program of a downstream firm, write:

$$X_{Ik}^* = \mu w_{k}^{1-\mu} P_{Ik}^{\mu-1} (f + x_{jk})$$

and

$$L_{Ik}^* = (1-\mu) w_{k}^{-\mu} P_{Ik}^{\mu} (f + x_{jk}), \quad \forall k \in \{1, 2\}$$

(3)

where $w_{k}$ is the wage rate prevailing in region $k$. $P_{Ik}$ is the price index of the intermediate input in region $k$. It is composed of the prices of intermediate goods sold in region $k$, produced either in the local region or in the distant one:

$$P_{Ik} = \left[\sum_{i=1}^{n_{Ik}} (p_{ik})^{1-\sigma} + \sum_{i=1}^{n_{Ik}'} (p_{ik'} (\tau + \phi n_{I}))^{1-\sigma}\right]^{\frac{1}{1-\sigma}}, \quad \forall k \in \{1, 2\}$$

(4)
where \( p_{ik} \) and \( p_{ik'} \) are the individual free-on-board (f.o.b) intermediate goods prices of a \( i \) variety produced respectively in \( k \) and \( k' \). From section 2, \( \tau + \phi n_I \) refers to the transfer cost of intermediate goods which encompasses both transport costs and (expected) coordination costs. Thus, the cost function of a typical downstream firm is given by: 

\[
C^*_jk = w_k^{1-\mu} P_{ik}^\mu (f + x_{jk}), \forall k \in \{1,2\}.
\]

Let \( c_{jk} \) represent the marginal cost a downstream firm in region \( k \), producing a variety \( j \) of final good. It is equal to: 

\[
c_{jk} = w_k^{1-\mu} P_{ik}^\mu, \forall k \in \{1,2\}.
\]

The global demand addressed to a variety \( i \), for \( i \in [1,n_{Ik}] \) of intermediate good is derived from the maximization program of the aggregate \( X_I \) with respect to the share of production cost spent on intermediate goods in region \( k \), for \( k \in \{1,2\} \). The total spending on intermediate goods in a given region is: 

\[
E_{Ik} = \mu n_{Ik} P_{ik} x_{jk}, \forall k \in \{1,2\}
\]

(5)

With \( x_{jk} = x_{jkk} + x_{jkk'} \), where \( x_{jkk} \) represents the amount of final good produced and supplied in the local market and \( x_{jkk'} \) represents the amount of final good locally produced and shipped to the distant market.

The maximization program of \( X_I \) with respect to equation (5) gives the following demand of intermediate good for any variety \( i \), produced in \( k \), from a downstream firm located in \( k' (\neq k) \):

\[
x_{ikk'}^d = E_{Ik'} P_{ik'}^{\sigma -1} (p_{ik} (\tau + \phi n_I))^{-\sigma}
\]

(6)

Notice that the demand function of an intermediate good produced in \( k \) from a local downstream firm is equal to:

\[
x_{ikk}^d = E_{Ik} P_{ik}^{\sigma -1} (p_{ik})^{-\sigma}
\]

(7)

Demand quantities of intermediate goods are lowered by the presence of coordination cost. This reinforces the incentives for upstream firms to locate close to their suppliers. Moreover, equation (6) shows that this coordination cost is not lowered by the fall in transport cost (\( \tau \)), downstream firms have more incentives to be close to their suppliers in order to save coordination cost. Indeed, when transport costs fall, the number of firms increases, which increases the coordination cost.

The profit of each downstream firm in region \( k \) is equal to: 

\[
\pi_{jk} = p_{jk} x_{jk} - w_k^{1-\mu} P_{ik}^\mu (f + x_{jk}), \forall k \in \{1,2\}.
\]

Thus, the price of any variety of final goods in region \( k \) is given by:

\[
p_{jk} = \frac{\sigma}{\sigma - 1} c_{jk}, \forall k \in \{1,2\}
\]

(8)
From the zero-profit condition, the supply of a variety $j$, for $j \in [1, n_{Fk}]$, of final good produced in $k$ for the local market ($k$) and for the distant one ($k'$) is:

$$x_{jk} = x_{jkk} + x_{jkk'} = f(\sigma - 1) \quad (9)$$

### 3.2 Upstream sector

The upstream sector in region $k$, for $k \in \{1, 2\}$, is composed of $n_{Ik}$ firms producing different varieties $i$, for $i \in [1, n_{Ik}]$, of intermediate goods. The production technology of intermediate goods requires only labor and takes the following form for a firm in region $k$:

$$L_{Ik} = f + x_{ik}, \forall k \in \{1, 2\} \quad (10)$$

where $L_{Ik}$ is the quantity of labor required to cover both the fixed cost $f$ and the variable cost $x_{ik}$. The cost function of an upstream firm in region $k$ is:

$$C_{ik} = w_{k}(f + x_{ik}), \forall k \in \{1, 2\}.$$ The marginal cost of an upstream firm in region $k$, producing a variety $i$ of intermediate good is then: $c_{ik} = w_{k}, \forall k \in \{1, 2\}$. Profit of a representative upstream firm is equal to:

$$\pi_{ik} = p_{ik}x_{ik} - w_{k}(f + x_{ik}), \forall k \in \{1, 2\}$$

The equilibrium price is:

$$p_{ik} = \frac{\sigma}{\sigma - 1}c_{ik}, \forall k \in \{1, 2\} \quad (11)$$

Introducing equation (11) into upstream profit equation, gives the global supply of intermediate goods ($x_{ik}$) in region $k$:

$$x_{ik} = x_{ikk} + x_{ikk'} = f(\sigma - 1), \forall k \in \{1, 2\} \quad (12)$$

### 3.3 Agricultural sector

The agricultural sector produces a freely tradeable homogeneous good $X_{A}$, under perfect competition. The production function is strictly concave:

$$X_{Ak} = F(L_{Ak}) = aL_{Ak}^\alpha, \forall k \in \{1, 2\}$$

with $\alpha \in [0, 1]$ and $a > 0$. Labor $L_{Ak}$ is the only input. Profits are equal to:

$$\pi_{Ak} = F(L_{Ak}) - w_{k}L_{Ak}, \forall k \in \{1, 2\}$$
The profit maximization program in agricultural sector gives the equilibrium amount of labor in agriculture:

\[ L^*_A_k = \left( \frac{w_k}{\alpha a} \right)^{\frac{1}{\alpha-1}}, \forall k \in \{1, 2\} \tag{13} \]

Introducing equation (13) in agricultural profit equation, gives equilibrium profit:

\[ \pi^*_A_k = a \left( \left( \frac{w_k}{\alpha a} \right)^{\frac{1}{\alpha-1}} \right) - w_k \left( \frac{w_k}{\alpha a} \right)^{\frac{1}{\alpha-1}}, \forall k \in \{1, 2\} \]. After some simplifications, the equilibrium profit rewrites:

\[ \pi^*_A_k = a \left( 1 - \alpha \right) \left( \frac{1}{\alpha} \right)^{\frac{\alpha}{\alpha-1}} w_k^{\frac{\alpha}{\alpha-1}} > 0, \forall k \in \{1, 2\} \tag{14} \]

The strictly positive profit comes from the concave technology of production. Profits are then Ricardian rents.

3.4 Consumers

Consumers have identical preferences between regions. They are endowed with the same Cobb-Douglas utility function. Their utility depends on the consumption of agricultural goods \( X_A \) and final goods \( X_F \). They account respectively for a share \((1 - \beta)\) and \(\beta\) of their income. Industrial goods consumption is characterized by a love for variety\(^6\). Their incomes are drawn, from wages \( w_k \) and profits in agricultural sector\(^7\) \( \pi^*_A_k \). The total spending on final goods in region \( k \) is denoted \( E_{F_k} \) and defined by:

\[ E_{F_k} = \beta (\pi^*_A_k + w_k L_k), \forall k \in \{1, 2\} \tag{15} \]

\( X_{F_k} \) is, similarly to \( X_{I_k} \), a composite of \( j \) varieties of final good, for \( j \in [1, n_F] \):

\[ X_{F_k} = \left( \sum_{j=1}^{n_{F_k}} x_{jk}^{\frac{\sigma-1}{\sigma}} + \sum_{j=1}^{n_{F_k'}} x_{jk}'^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \forall k \in \{1, 2\} \]

Where \( x_{jk} \) are quantities of final good produced in \( k \) and supplied to local market \((k)\) and \( x_{jk'} \) are quantities produced in the distant market \( k' \) and sent to \((k)\). Notice that \( \sigma \) (\( \sigma > 1 \)) is the elasticity of substitution between two different varieties. The final demand for a variety \( j \) addressed by consumers to downstream firms in \( k \) comes from local \( x_{jk}^d \) and distant market \( x_{jk'}^d \).

\(^6\) Similarly to the downstream sector, it ensures that consumers will buy as many varieties as available in the economy.

\(^7\) Following Venables (1996), it is assumed that agricultural profits are equally divided among farmers. Industrial sectors have no profits since the non-profit condition holds in the long-run equilibrium.
Thus, final demand is:
\[ x^d_{jk} = x^d_{jkk} + x^d_{jkk'}, \forall k \in \{1, 2\} \]

Consumer demands for a variety \( j \) of final good produced in \( k \) and purchased in \( k \) and \( k' \) are respectively:
\[
\begin{align*}
  x^d_{jkk} &= E_{Fk} P_{Fk}^{\sigma^{-1}} p_{jk}^{-\sigma}, \forall k \in \{1, 2\} \\
  x^d_{jkk'} &= E_{Fk'} P_{Fk'}^{\sigma^{-1}} (p_{jk} \tau)^{-\sigma}, \forall k \in \{1, 2\}
\end{align*}
\]

The price index in region \( k \) is:
\[
P_{Fk} = \left[ \frac{n_{Fk}}{\sum_{j=1}^{n_{Fk}} (p_{jk})^{1-\sigma}} + \frac{n_{Fk'}}{\sum_{j=1}^{n_{Fk'}} (p_{jk'})^{1-\sigma}} \right]^{-\frac{1}{1-\sigma}}, \forall k \in \{1, 2\}
\]

The clearance condition of labor market is:
\[
L_k = L^*_A + n^*_F L^*_F + n^*_I L^*_I, \forall k \in \{1, 2\}
\]

Where \( L_k \) is the total labor supply.

4 Coordination costs as a limit to redispersion: sustainability of the core-periphery equilibrium

In this model, the presence of coordination cost strengthens upstream-downstream linkages. In this section, I assess the condition on \( \phi \) under which the CP equilibrium is sustainable for low value of transport costs. Since this cost is borne by downstream firms, I specify the conditions under which the CP equilibrium is sustainable in the downstream sector.

The analysis of the sustainability of an equilibrium asks the following question: if all industrial activities are concentrated in only one region, do some firms have the incentives to move to the other region? If firms have incentives to move, that means that the CP configuration is not sustainable. To answer this question, I follow the methodology of Puga (1999), in studying the limit of the ratio of the demand addressed to a deviant firm toward the periphery to the demand addressed to a firm in the core region for low value of transport costs. Moreover as the introduction of coordination cost only alters the demand for intermediate goods from downstream firm, the analysis of demand will be done for this sector.

Let assume that the agglomeration of industrial activities takes place in region 1. The demand for final goods addressed to a firm in region 1 is \( x_{j1} \). This demand comes from local consumers \( (x_{j11}) \) and from consumers in region 2 \( (x_{j12}) \). If this CP configuration is an equilibrium, it means that profits are equal to zero in region 1. As industrial production only takes place in region 1, the total industrial demand is satisfied by firms located in region 1. What
will happen then if a firm leaves region 1 to region 2?

Price indexes in downstream sector in regions 1 and in region 2 can be expressed as:

\[ P_{F1} = n_{F1}^{1} p_{j1} \]  \hspace{1cm} (20)

\[ P_{F2} = n_{F1}^{1} p_{j1} \tau \]  \hspace{1cm} (21)

At the equilibrium, prices are equal for all varieties so the price index depends on the number of varieties. Then, we look at final goods prices, which are equal to:

\[ p_{j1} = \sigma_{1} c_{j1} \]  where  \[ c_{j1} = w_{1}^{1-\mu} P_{F1}^{\mu} \]

\[ p_{j2} = \sigma_{2} c_{j2} \]  where  \[ c_{j2} = w_{2}^{1-\mu} P_{F2}^{\mu} \]  \hspace{1cm} (22)

Where price index of intermediate good are defined similarly to price index of final good, except that intermediate goods bear coordination cost:  \[ P_{I1} = n_{I1}^{1} p_{i1} \]  and  \[ P_{I2} = n_{I1}^{1} p_{i1} (\tau + \phi n_{I}) \].

Plugging equation (22) into demand functions (16) and (17) yields:

\[ x_{j1} = \frac{E_{F1} + E_{F2}\tau^{-1}}{n_{F1} p_{j1}} \]  and  \[ x_{j2} = \left( \frac{w_{1}}{w_{2}} \right)^{1-\mu} (\tau + \phi n_{I})^{-\mu} \left( \frac{E_{F1} \tau^{-\sigma} + E_{F2} \tau^{\sigma-1}}{n_{F1} p_{j1}} \right) \].

The sustainability of CP configuration is shown through the limit of  \[ \frac{x_{j2}}{x_{j1}} \]  for small value of transport costs. If  \[ \lim_{\tau \to 1} \left( \frac{x_{j2}}{x_{j1}} \right) < 1 \]  , CP configuration is sustainable. Conversely, if  \[ \lim_{\tau \to 1} \left( \frac{x_{j2}}{x_{j1}} \right) > 1 \]  , CP configuration is unsustainable.

Then, the ratio of final goods demand is given by:

\[ \frac{x_{j2}}{x_{j1}} = \left( \frac{w_{1}}{w_{2}} \right)^{\sigma(1-\mu)} (\tau + \phi n_{I})^{-\sigma \mu} \tau^{-\sigma} \left( 1 + \frac{E_{F2} (\tau^{2\sigma-1} - 1)}{E_{F1} + E_{F2} \tau^{-1}} \right) \]  \hspace{1cm} (23)

After some simplifications the limit of final goods demand can be written as:

\[ \lim_{\tau \to 1} \left( \frac{x_{j2}}{x_{j1}} \right) = \left( \frac{w_{1}}{w_{2}} \right)^{\sigma(1-\mu)} (1 + \phi n_{I})^{-\sigma \mu} \]  \hspace{1cm} (24)

The limit depends on  \[ \frac{w_{1}}{w_{2}} \],  \[ \phi \],  \[ n_{I} \]. Wages ratio and the number of intermediate varieties  \[ n_{I} \] are endogenously determined. However, a simple relationship between  \[ \frac{w_{1}}{w_{2}} \],  \[ \phi \] and  \[ n_{I} \] can be established such as the CP configuration is unsustainable. This leads to the determination of a value of  \[ \phi \] for which the CP
configuration is sustainable:

\[
\phi > \left( \frac{w_1}{w_2} \right)^{\frac{1-\mu}{\sigma}} - 1
\]

(25)

The right hand side of this equation is the critical value of \( \phi \). As long as the value of \( \phi \) respects this condition, agglomeration stands. However, for a value of \( \phi \) lower than the critical value, downstream firms have more incentives to locate in periphery in order to benefit from interregional wage differential \( \left( \frac{w_1}{w_2} \right) \) than to be close to their supplier because the coordination cost is low. This critical value is an increasing function of the wage ratio. The greater is the relative wage in region 1, the stronger is the incentive for firms to move in periphery, and thus, the greater must be the coordination cost to halt redispersion. On the other hand, the critical value negatively depends on the complexity of the production process: the greater the complexity, the less coordination cost needs to depend on it to halt redispersion. To summarize, in this model, the nature of the relation between the degree of agglomeration and the level of transfer cost is determined by the level of coordination cost. Then, compared to Venables, in this model firms face an additional trade-off even for low values of transport cost. Indeed, unlike in Venables (1996), a decrease in transport cost is not sufficient to involve redispersion despite wage differential favoring the periphery region.

Graphic 1 pictures \( \left( \frac{w_1}{w_2} \right)^{\sigma(1-\mu)} (1 + \phi n_I)^{-\sigma \mu} \) as a function of \( \phi \) in simulations performed with the same parameters as Venables. The critical value of \( \phi \) is close to 0.0058. For smaller values of \( \phi \), the wage differential offsets the coordination problem, and the CP structure becomes unsustainable for low values of \( \tau \). Conversely, for greater values of \( \phi \), when \( \tau \to 1 \), the coordination cost remains a strong enough centripetal force to halt the redispersion of industrial activities.

[Fig. 1 about here.]

Even if \( \phi \) is bellow the critical value, it can postpone the redispersion, for \( \tau > 1 \): with the above mentioned parameters, redispersion occurs for \( \tau = 1.1 \) in the Venables model. By setting \( \phi = 0.0001 \), a value much smaller than the critical one, CP configuration is still sustainable at \( \tau = 1.1 \). In this case, the

---

8 In a more general setting, with a coordination cost given by \( \psi(n_I) \), with \( \psi' > 0 \), this equation would simply write \( \psi(n_I) > \left( \frac{w_1}{w_2} \right)^{\frac{1-\mu}{\sigma}} - 1 \).

9 Notice that, in this expression, \( \phi \) appears not only directly but also through \( n_I \), \( \omega_1 \) and \( \omega_2 \) that are endogenous variables.

10 \( \alpha = 10/11, \beta = 0.2, \sigma = 6, a = 1.2, L_1 = L_2 = 20 \) and \( \mu = 0.5 \).
coordination cost \((\phi n_I)\) accounts for less than 1% of the total transfer cost \((\tau + \phi n_I - 1)\). This figure should be compared with the empirical findings of Anderson and van Wincoop (2004), who estimate that information costs account for not less than 6% of the global transfer cost.

5 Concluding remarks

Within the NEG literature, as soon as labor is immobile and input-output linkages are strong, the relationship between the degree of agglomeration and the level of transport is "Reverted U-shaped". Nevertheless, despite the low labor mobility and the strength of input-output linkages in Europe and an advanced integration process, massive redispersion of industrial activities toward Eastern and Central European countries is not observed. In this paper, I showed that uncertainty in distant input-output linkages, emphasized by the NNTT, can explain this phenomenon. The introduction of this uncertainty through the coordination cost in the Venables framework highlights that a fall in transport costs is not sufficient to bring about the redispersion of industrial activities. According to this explanation, European firms would be reluctant to migrate to the periphery because the European integration process does not reduce the coordination problem posed by distant offshoring.

The policy implications of this paper are different from the ones deduced from the genuine Venables’ model. Indeed, according to Venables’ results, redispersion could be promoted by the improvement of the accessibility of peripheral regions (a decrease in \(\tau\)). On the other hand, the model presented in this paper advocates policy tools of legal and informational nature: not only should the moving firms be able to supply their customers at a low transport cost, but the downstream firms staying at the core should be helped monitoring their suppliers to avoid a great coordination cost (a decrease in \(\phi\)).

NEG authors usually present iceberg transport cost as an aggregate of all sort of transfer costs, including information or transaction costs. However, the results presented in this paper highlight the need to discriminate between both kinds of cost. Determining which of the so-called integration policies lower \(\tau\) and which lower \(\phi\) constitute a stimulating research agenda.
References

Tassinopoulos, A., Werner, H., 1999. To move or not to move U migration of labour in the european union. IAB Labour Market Research Topics 35.
Figures

Fig. 1. The critical value of phi