Permanent uncertainty, employment protection, and firms’ location

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November 2012 - WP 2012-40
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first version: january 2012, this version: november 2012

Abstract
It is often argued that firms need flexibility in order to better face demand uncertainty. As employment protection legislation (EPL) impacts the cost of volume adjustments available to firms, it constrains the volume flexibility that they can achieve. Weakening EPL might thus be thought of as a desirable policy, in particular for when firms are deciding where to locate. On the other hand, it is well known that in an oligopolistic setting, flexibility is not necessarily an advantage. The aim of this paper is to analyze the consequences that different EPL regimes may have on firms’ location decisions. It shows that the country characterized by the strongest EPL can nevertheless attract firms under demand uncertainty (either in an agglomeration equilibrium, or in a dispersion equilibrium), and highlights the respective and combined roles played by trade costs and strategic interaction. Moreover, it shows that if firms compete in prices, they will never agglomerate in the country with the lowest EPL.

Keywords: oligopoly, strategic behavior, commitment, flexibility, employment protection, trade costs, firms’ location.

JEL classification: F12, F16, L13

Acknowledgement The author would like to thank the following for their helpful comments: Pascal Billand, Daniel Danau, Bernard Franck, Frederic Garrel, Isabelle Lebon, Pierre-Jean Messe and Thierry Madies; as well as the participants of the CREM-seminar, the Thematic Meeting of The French Economic Association "Economic Geography and Public Policies" (Saint Etienne - May 10-11, 2012), and the interdisciplinary conference "Trajectories, Employment and Public Policy" (Caen - June 14-15, 2012).

1 Introduction
It is often argued that firms need flexibility in order to better face demand uncertainty. The fact that the degree of volume flexibility a firm can achieve is constrained by the labor flexibility allowed by employment protection legislation
(hereafter EPL) has led certain economists to propose a relaxation of employment protection. Further, the question of the effect that EPL might have on firms’ performance becomes crucial when firms are deciding where to locate.

The aim of this paper is to examine whether a strong EPL is necessarily detrimental to domestic industry.

This involves two linked issues:

Does a strong EPL necessarily deter firms from locating in the country where it prevails?

If not, when firms locate in countries with different levels of employment protection, where may they receive greater expected profits?

Given that international transactions are due mainly to a few large firms (see Bernard et al., 2007), an oligopolistic setting seems to be the appropriate framework within to address which these questions.

Surprisingly, this question of the link between EPL and the location decisions of oligopolistic firms has received very little attention in the theoretical literature.

The very sparse theoretical literature on EPL and location has focused primarily on the effect that EPL has on location in the case of an uncertain future shock on the market.

Most of these few papers consider a monopoly. Considering the entry decision of a single firm whose future (perfectly integrated) market faces possible collapse, Haaland, Wooton and Faggio (2003) show that worker protection deters potential investment, due to higher exit costs. Adopting similar assumptions, but considering a monopoly facing a non-catastrophic possible shock on future demand, Dewit, Görg and Montagna (2009) show that, on the one hand, employment protection deters entry, but, on the other hand, that it favors domestic anchorage by discouraging relocation. The firm may then choose to locate in the country with the strongest EPL if the cost of setting up a plant in this country is sufficiently low.

Closer to the analytical framework deployed in this paper, Dewit, Leahy and Montagna (2003, 2012) analyze location decisions in a duopoly framework with an uncertain future demand. This allows them to take strategic considerations into account. In particular, when firms offer substitute goods and compete in quantities, employment protection (which yields higher volume adjustment costs for the domestic firm when it changes its output level between the two periods) enables the firm to commit to a higher future output level and favors domestic anchorage. In such a framework, strategic agglomeration can occur in the country in question. This arises if demand uncertainty and specific FDI costs are not too high (specific FDI costs being the costs incurred by a firm

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1In fact, on the one hand, most of the OECD countries appear to have reduced their levels of employment protection in the recent decades (see OECD (2004)); on the other hand, the United States has generalized the "experience rating" system, in which firms are taxed on the basis of their experience with dismissals. Many economists have recommended the adoption of such a system in other countries (see, e.g., Blanchard Tirole (2003) for France). Although the experience rating system is a particular method of financing unemployment insurance designed to avoid free riding by companies with high layoff rates, it nevertheless constitutes a form of employment protection, albeit one that is not integrated into the OECD Indicators.
whose headquarters are located in a different country from the one in which
it is setting up a plant). In addition, specific FDI costs are needed for the
emergence of a dispersion equilibrium.

The present paper considers firms which are setting up only one plant each
(as in Dewit, Leahy and Montagna 2003, 2012), but does not assume an exoge-
 nous nationality for firms. Moreover, it differs from the papers mentioned above
in that it is devoted to the analysis of the effect of EPL on location of oligopolis-
tic firms under permanent uncertainty of demand, rather than under uncertain
future demand. This means that the demand level (the demand intercept) is
thought of as random in each period, but without exhibiting any intertemporal
dependence. This means that postponing the location decision does not provide
any additional information, since firms face the same uncertainty irrespective
of the date. Due to this assumption of "permanent" uncertainty, we are not
here concerned with the desirability of possible relocation after learning the de-
mand level, nor with determining the optimal date of entering. What is studied
is whether volume flexibility, which permits a firm to accommodate such un-
certainty and which is allowed by weak EPL, always constitutes a competitive
advantage, and further, whether only countries with a weak EPL can attract
firms.

The relevant literature here is that which concerns the tradeoff between
flexibility and commitment under uncertainty and strategic substitutes.

As is well known by industrial economists, flexibility is not necessarily an
advantage in such a competitive setting. For example, when oligopolistic firms
compete in quantities within the market of a homogeneous good, there is a first-
mover advantage: given that quantities are then strategic substitutes, the higher
the first mover’s output is, the lower the second mover’s output must be in order
to avoid too low a price. But under demand uncertainty, this second mover’s
disadvantage can be counterbalanced by the informational benefit a firm can
get in postponing production.

Such a tradeoff between commitment and flexibility has been studied by
Spencer and Brander (1992), who showed that when a duopolistic firm is flexi-
 ble while its competitor is not, the committed firm gets a higher expected profit
than the flexible firm, provided that the demand uncertainty is not too high.
However, when firms choose their technologies (whether flexible or non-flexible),
such an asymmetric equilibrium (i.e. an equilibrium where firms choose differ-
ent technologies) does not emerge: both firms will choose the flexible technology
if the uncertainty is sufficiently high, and the non-flexible technology if the un-
certainty is sufficiently low. This model could be used to examine the impact
of EPL on firm location. If flexibility can be achieved only in the country with

\footnote{The present paper implicitly assumes that each firm locates its plant and its headquarters
in the same country.}

\footnote{For an analysis of strategic interaction under certainty, see, for example, Tirole (1989).}

\footnote{Such a result regarding the impossibility of asymmetric equilibria comes from the assump-
tion that the committed firm cannot vary its output \textit{ex post}. If any committed firm could
\textit{ex post} and costlessly increase its quantity (but not reduce it), only asymmetric equilibria
would emerge (see Maggi, 1996): one firm would choose the non-flexible technology whereas
the other would choose the flexible one.}
the weakest EPL, choosing in which country to locate is identical to choosing whether to be flexible or not. In this case, according to the Spencer-Brander results, there is no room for an asymmetric location equilibrium: firms agglomerate in the country with the strongest EPL if uncertainty is low, and in the other country otherwise.

However, this result holds for a perfectly integrated market (Spencer and Brander considered a unique market). In fact, consumers are also located in a specific country and generally do not have the option of exerting inter-market arbitrage. Moreover, firms have to bear trade costs in accessing to foreign markets.

The aim of the present paper is to analyze the impact that different EPL regimes across countries may have upon the location decisions of oligopolistic firms facing a permanent demand uncertainty in each of the internationally segmented markets. It will show, firstly, that under these assumptions, an asymmetric location equilibrium (an equilibrium with a firm in each country) can emerge – something which is not possible in the Spencer-Brander model –, and secondly, that in such an equilibrium, the firm located in the country with the strongest EPL may receive a higher expected profit than its flexible competitor.

The structure of the paper is as follows. Section 2 presents the basic model and highlights the roles played by trade costs, firms' strategic behavior and "total "uncertainty. Section 3 discusses the results by introducing some alternative assumptions: Subsection 3-1 introduces the possibility that a firm whose location enables it to achieve perfect production flexibility might nevertheless adopt the non-flexible technology; Subsection 3-2 discusses what might be expected if quantity commitment allows some degree of flexibility; and Subsection 3-3 explains why, contrary to what might be expected, price competition does not result in agglomeration in the country with the lowest EPL. Section 4 concludes.

2 The model

The market is that of a homogenous good. The option of storage is excluded (due either to the non-storable nature of the good or to prohibitive storage costs).

There are two countries (S and W), whose markets are internationally separated (meaning that consumers cannot exert arbitrage between the two markets).

The present paper deals with an issue which is close to that addressed by Haufler and Wooton (2010). These authors study a model where countries of different sizes compete to attract an exogenous number of oligopolistic firms. They use a general equilibrium model and focus on the impact of economic integration (reduction of trade costs) under tax competition. The present paper differs from theirs in several aspects (partial equilibrium framework, only two firms, countries of similar sizes but with different EPL levels), but the question it addresses is similar: How do different policies across countries influence oligopolistic firms’ location decisions, and how does economic integration impact this?
Demand fluctuates in each market. In market $k$, the demand function is $q = a + \varepsilon_k - p$, where $q$ is the quantity, $p$ the price, $a$ a strictly positive constant and $\varepsilon_k$ a random variable with mean 0 and variance $\sigma_k^2$. As usual, the lowest bound of $\varepsilon_k$ is assumed to be high enough to exclude shutdown for a flexible firm facing a non-flexible rival.

There are two firms, firm $A$ and firm $B$, which have to choose their locations.

Firms operate in their domestic markets at a zero marginal cost of production and incur a unit trade cost $t$ in serving their foreign markets (this trade cost may be a transport cost). As usual, the set-up cost incurred by a firm in installing a plant abroad is assumed to be large enough to exclude multiplant firms. For expositional convenience and because potential entry is outside the purpose of this paper, other fixed costs are neglected.

Firms compete in quantities. They are assumed to be risk neutral.\textsuperscript{6}

The countries differ with respect to their employment protection legislation regimes.

As a primary hypothesis, it is assumed that the technology available to a firm is constrained by the EPL which applies in the country where it is located. More precisely, in country $S$ – the one with strong EPL – firms cannot adjust their employment levels in response to uncertainty, whereas in country $W$ – with a weak EPL – the employment level can be adjusted without any cost. This corresponds to the two extreme cases of technological flexibility à la Turnovsky (1973);\textsuperscript{7} it is as if a firm located in country $W$ produced \textit{ex post} (i.e. after knowing the value of the demand intercept on each market) whereas a firm located in country $S$ produced \textit{ex ante} (i.e. before knowing the value of the demand intercept on each market).

The timing of the game is as follows.

In the first stage, firms simultaneously choose their locations.

The second stage is the quantity stage, and involves two sub-stages. In the first sub-stage, firms located in country $S$, if there are any, choose their quantities \textit{ex ante}. In the beginning of the second sub-stage, demands are known, and then firms located in country $W$, if there are any, choose their quantities. Firms then receive their profits.

As usual, the outcome of the subgame perfect equilibrium is determined by backward induction.

\section{The quantity stage}

Given the links between EPL and technology, the competitive structure of the quantity stage depends on the locations chosen in the first stage. There are three kinds of subgames: two yielding a Cournot equilibrium (either flexible or

\textsuperscript{6}This assumption is justified by the opportunity for portfolio diversification as available to shareholders. Moreover, avoiding risk is less crucial in such a model of "permanent" uncertainty – where good states of nature may precede bad ones or follow them – than it would be in a model with an uncertain future demand.

\textsuperscript{7}The impossibility of \textit{ex post} adjustment corresponds to an infinite cost for \textit{ex post} adjustments.
non-flexible) and one yielding a Stackelberg equilibrium. This latter corresponds to each subgame following heterogeneous locations: the firm located in country \( S \) choosing its quantity \( \text{ex ante} \) whereas its rival produces \( \text{ex post} \) and then adjusts its quantity to that of the other firm, the former firm thus becomes a Stackelberg leader while its competitor becomes a Stackelberg follower.

Appendix 1 provides the calculations of the equilibria.

2.1.1 The flexible Cournot equilibrium

This equilibrium occurs when both the firms are located in country \( W \).

The equilibrium expected profit of each firm is then:

\[
CF = cf + cf_t = \left[ a^2 + (a - t)^2 \right]/9 + (\sigma_S^2 + \sigma_W^2)/9
\]  

(1)

2.1.2 The non-flexible Cournot equilibrium

This equilibrium occurs when both the firms are located in country \( S \).

The equilibrium expected profit of each firm is then:

\[
CNF = cnf + cnf_t = \left[ a^2 + (a - t)^2 \right]/9
\]  

(2)

2.1.3 The Stackelberg equilibrium

This equilibrium occurs when a firm (say, firm \( A \)) is located in country \( S \) while the other firm (say, firm \( B \)) is located in country \( W \).

As already mentioned, firm \( B \) can adjust its output level to uncertainty whereas firm \( A \) cannot do this and has to produce \( \text{ex ante} \). So, firm \( A \) is the Stackelberg leader and firm \( B \) is the follower.

The equilibrium expected profits are then:

- for the leader:

\[
L^{RD} = l + l_t = [(a + t)^2 + (a - 2t)^2]/8
\]  

(3)

- for the follower:

\[
F^{RD} = f + f_t = [(a + 2t)^2 + (a - 3t)^2]/16 + (\sigma_S^2 + \sigma_W^2)/4
\]  

(4)


2.2 The location stage

In the first stage, firms simultaneously choose their locations. These decisions are taken \( \text{ex ante} \) on the basis of expected profits that will be earned in the second stage for each location pair.
The following matrix gives the expected profits given the locations (either in country $S$ or $W$).

<table>
<thead>
<tr>
<th>firm A</th>
<th>S</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S$</td>
<td>$CNF, CNF$</td>
<td>$L^{RD}, F^{RD}$</td>
</tr>
<tr>
<td>$W$</td>
<td>$F^{RD}, L^{RD}$</td>
<td>$CF, CF$</td>
</tr>
</tbody>
</table>

Thus, the location equilibria are:
- $(S, W)$ and $(W, S)$ if $L^{RD} > CF$ and $F^{RD} > CNF$, \(^8\)
- $(W, W)$ if $L^{RD} < CF$, \(^9\)
- $(S, S)$ if $L^{RD} > CF$ and $F^{RD} < CNF$.

A Stackelberg equilibrium therefore arises if and only if:
$$\frac{1}{\alpha} \left(14 - 14t/a - 101(t/a)^2\right) = \frac{1}{\alpha} \left(h(t/a) - \frac{1}{\alpha} \left(2 - 27t/a + 7(t/a)^2\right) - \frac{1}{\alpha} \left(2 - 2t/a + 37(t/a)^2\right)\right)$$
$$\frac{1}{\alpha} \left(2 - 2t/a - 3(t/a)^2\right) = \frac{t/a}{\alpha} \left(\frac{1}{\alpha} \left(2 - 2t/a + 37(t/a)^2\right)\right)$$

In this equilibrium, the firm located in country $S$ earns a higher expected profit than its competitor if and only if $h(t/a) = (\sigma_S^2 + \sigma_W^2)/a^2$, that is, if trade costs are not too high.

Figure 1 maps the location equilibria.

**Proposition 1** When markets are internationally segmented,

1. a dispersion equilibrium (a Stackelberg equilibrium) emerges if and only if parameters are such as $f(t/a) < (\sigma_S^2 + \sigma_W^2)/a^2 < g(t/a)$ (zones 1 and 2 in figure 1). \(^{10}\)

   In the Stackelberg equilibrium, the higher expected profit is that of the firm located in the country with the strongest EPL (i.e. the Stackelberg leader) if and only if $h(t/a) > (\sigma_S^2 + \sigma_W^2)/a^2$ (zone 2 in figure 1).

2. firms agglomerate in country $W$ if and only if parameters are such as $(\sigma_S^2 + \sigma_W^2)/a^2 > g(t/a)$.

3. firms agglomerate in country $S$ in the other cases.

### 2.3 The roles played by strategic interaction, trade costs, and "total uncertainty"

Considering zero trade costs enables us to isolate the combined roles of uncertainty and strategic interaction. It should be noted that the case of null trade

\(^{8}\)Note that if firms chose their locations sequentially, a unique equilibrium would exist. The first-mover would choose to locate in country $S$ (respectively, $W$) if $L^{RD} > F^{RD}$ (respectively, $L^{RD} < F^{RD}$), and the second-mover would choose to locate in the other country.

\(^{9}\)If $L^{RD} < CF$ and $F^{RD} < CNF$, there are two location equilibria, $(S, S)$ and $(W, W)$, but the latter pareto-dominates the former. We then presume that in this latter case, both firms locate in country $W$. Note that if firms chose their locations sequentially, there would exist a unique equilibrium $(W, W)$.

\(^{10}\)The relative values of $t/a$ which allow the emergence of the dispersion equilibria are not as high as they might seem. Indeed, the model runs with a marginal cost of production which is equal to zero. Taking $c$ as a strictly positive marginal cost of producing would consist in replacing $a$ by $a - c$ in each equation. The x-axis in figure 1 would be $t/(a - c)$ instead of $t/a$. The y-axis would be $(\sigma_S^2 + \sigma_W^2)/(a - c)^2$ instead of $(\sigma_S^2 + \sigma_W^2)/a^2$. 

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costs is similar to that studied in the Spencer-Brander model. As already mentioned, the quantity equilibrium in each subgame results from a trade-off between, on one hand, the strategic advantage tied to quantity commitment, and, on the other hand, the informational benefit provided by flexibility. So, in each subgame following heterogeneous locations, the committed firm earns a higher expected profit than its flexible rival if the level of uncertainty is low enough. But when \( t = 0 \), the firm earning the lowest expected profit in the dispersion (i.e. Stackelberg) configuration finds it better to locate in the same country as its rival, that is, in country \( W \) (respectively, \( S \)) for a sufficiently high (respectively, low) level of total uncertainty as given by \( (\sigma_3^2 + \sigma_W^2)/\alpha^2 \), so that only agglomeration equilibria can emerge. These location equilibria are represented on the y-axis in figure 1.

Looking at open-loop equilibria in the quantity stage enables us to isolate the role played by trade costs. Open-loop equilibria rely on the assumption that firms choose their quantities without taking into account the strategic effect of such decisions. As seen above, the strategic impact of quantity decisions concerns the committed firm facing a flexible competitor. The open-loop assumption then means that the firm located in country \( S \) (say, firm \( A \)) chooses, for market \( k \), the quantity which maximizes the expected profit it earns in this market, without anticipating the reaction function of firm \( B \), the firm located in country \( W \).

Appendix 2 provides the equilibrium calculations under this assumption.

Figure 2 maps the location equilibria resulting from this assumption. This permits us to highlight the pure effect of trade costs on location decisions: as trade costs favor dispersion for any given level of uncertainty, high enough trade costs counterbalance the informational advantage tied to flexibility.

\[ \text{<insert figure 2 here>} \]

The combined roles of trade costs and strategic interaction works as follows. As trade costs to some extent protect the domestic market from foreign competition when firms locate in different countries (in the way that they give the domestic firm a cost advantage), the Stackelberg expected profits of both firms are increasing with trade costs. On the other hand, when both the firms locate in the same country, neither gets a cost advantage over its competitor and the competition becomes maximum in each market. As firms have to incur trade costs in serving their foreign markets, the Cournot expected profits are decreasing with trade costs. This explains why sufficiently large trade costs are needed to prevent firms from deviating from the Stackelberg duopoly to a Cournot duopoly, and then for allowing the emergence of a Stackelberg equilibrium. An interesting consequence of this result is tied to transport costs: if the trade costs involved are mainly transport costs, a dispersion equilibrium becomes more likely, since trade costs are expected to rise due to increasing energy costs.

\(^{11}\) The Spencer-Brander model considers a unique market, corresponding in our model to \( t = 0 \), \( \sigma_3^2 = \sigma_W^2 = \alpha^2 \) (then \( \sigma_3^2 + \sigma_W^2 = 2\alpha^2 \)) and to a demand intercept equal to \( 2\alpha \).
Concerning the differential in expected profits which arises in the dispersion equilibrium, it should be noted that the domestic market protection due to trade costs becomes stronger as the foreign competitor’s output becomes higher. Therefore, such protection is more beneficial to the Stackelberg follower which tends to produce less than the leader, and explains why $L^{RD} - F^{RD}$ is decreasing with trade costs.

Another point meriting clarification is why total uncertainty matters, whereas the differential in uncertainties does not, in determining the location equilibria. Understanding this point calls for us to remark that the expected profit of a (perfectly) flexible firm involves two independent parts. The first part may be called the informational benefit, which Ot (1961) has shown to be increasing with uncertainty. This results from the convexity of the quantity equilibrium profit in the random variable and yields an expected profit increasing with the variance of the random variable. The second part is what Lecostey (1994) calls the "comparable certain profit", that is, the profit that would be earned, under the same competitive structure (either Cournot or Stackelberg), by a flexible firm facing a demand for which the intercept equals the expected value of the random intercept. Trade costs affect only the "comparable certain profit", explaining why the differential in uncertainty does not matter in determining the location equilibria.

Finally, the model provides the following interesting interpretation that could be used in empirical work. If market integration can be thought of as a reduction in trade costs (represented as a horizontal shift in figure 1), it can be expected that increased market integration favors agglomeration in the country with the weakest EPL when the sectoral uncertainty is high, whereas it results in agglomeration in the country with the strongest EPL when the sectoral demand uncertainty is lower. This is due to the strategic behavior of firms, since in the absence of such a behavior, the reduction of trade costs always favors agglomeration in the country with the weakest EPL, as seen under the open-loop assumption. Unfortunately, the existing empirical studies of the effect of EPL on FDI do not permit us to check these predictions, since, first, these studies generally work on national aggregate data rather than on sectoral data, and second, they never introduce a proxy for (permanent) uncertainty as an explanatory variable.

2.4 Section conclusion

In this section, only two extreme cases of flexibility were considered: perfect flexibility – i.e. costless ex post adjustment in quantities – and overall lack of flexibility – which corresponds to infinite ex post adjustment costs.

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12The empirical literature generally concludes that employment protection deters inward FDI (Görg 2005; Javorcik and Spatareana 2005; Dewit, Görg, and Montagna 2009)), that it favors domestic anchorage (Dewit, Görg, and Montagna 2009), or that there is a nonlinear relationship (u-shaped) between employment protection level and FDI (Radulescu and Robson 2003).
This framework had enabled us to highlight the trade-off between flexibility and strategic commitment without having to introduce additional parameters to represent differences in flexibility.

In such a framework, which is very favorable to flexibility,\(^{13}\) it has been shown that the country with the strongest EPL can nevertheless attract firms, and that the domestic firm may achieve higher expected profits than its foreign (flexible) competitor.

3 Alternative or additional assumptions

This section relaxes or alters some assumptions of the above section and checks whether or not this favors locating in country \(W\).

3.1 Assuming no constraint on technology in country \(W\)

In Section 2, it was assumed that EPL constrained the domestic firms’ technology: in the country with a strong EPL (country \(S\)), volume flexibility was prohibited, whereas in the country with weak EPL (country \(W\)), firms were allowed to adjust their output.

However, it might be thought that a firm located in country \(W\) might choose to commit itself to some output volume by offering stable contracts to its employees and adopting a non-flexible technology.\(^{14}\)

Under such an assumption, two new kinds of equilibria must be taken into account in the quantity stage.

In the first, although there is a firm in each country, the firm located in country \(W\) adopts a non-flexible technology (as does its foreign competitor).

The equilibrium is then a (non-flexible) Cournot one with some reciprocal dumping and corresponds to the non-flexible Cournot equilibrium of appendix 1, taking \(c_A = 0\) and \(c_B = t\) in market \(S\) and the reverse in market \(W\).

The equilibrium expected profit of a firm is then:

\[
CNF^{RD} = \frac{(a - 2t)^2 + (a + t)^2}{9}
\]

Note that \(CNF^{RD} > CNF\). Indeed, since there is a firm in each country, each of them gets a cost advantage in its domestic market due to trade costs and therefore gets a higher expected profit than it earned in the case described in Section 2, where both the non-flexible firms locate in country \(S\).

\(^{13}\)The reader may easily check that within such a framework, a monopoly would always choose flexibility (i.e. would locate in the country with the weakest EPL) as soon as there is demand uncertainty).

Further, in a duopolistic setting, the fact that committed firms cannot increase their outputs \(ex \ post\) favors agglomeration equilibria to the detriment of dispersion equilibria, as might be expected from comments in n. 4.

\(^{14}\)The assumption in Section 2 that weak EPL constrains the domestic firms to be flexible relies on the hypothesis that, due to the positive connotation of the term "flexibility", firms’ managers may have some difficulties convincing shareholders that it could be better to renounce flexibility. The present subsection relaxes this assumption.
The second kind of equilibrium which may occur is that where both the firms are located in country \( W \) but have chosen different technologies. This yields a Stackelberg equilibrium in which expected profits are obtained by taking \( c_A = c_B = 0 \) in market \( W \) and \( c_A = c_B = t \) in market \( S \).

Then the expected profits are:
- for the leader:
  \[ L = \frac{a^2 + (a - t)^2}{8} \]
- for the follower:
  \[ F = \frac{a^2 + (a - t)^2}{16} + \frac{(\sigma_S^2 + \sigma_W^2)}{4} \]

Note that \( L < L^{RD} \) and \( F < F^{RD} \), since none of the firms has a cost advantage in any market.

Assuming that the choices of location and of technology (when this latter is allowed) are made simultaneously, the expected profit matrix to take into account for the location and technology stage becomes:

<table>
<thead>
<tr>
<th>firm A</th>
<th>( S )</th>
<th>( W_F )</th>
<th>( W_{NF} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( S )</td>
<td>( CNF, CNF )</td>
<td>( L^{RD}, L^{RD} )</td>
<td>( CNF^{RD}, CNF^{RD} )</td>
</tr>
<tr>
<td>( W_F )</td>
<td>( F^{RD}, F^{RD} )</td>
<td>( CF, CF )</td>
<td>( F, L )</td>
</tr>
<tr>
<td>( W_{NF} )</td>
<td>( CNF^{RD}, CNF^{RD} )</td>
<td>( L, F )</td>
<td>( CNF, CNF )</td>
</tr>
</tbody>
</table>

Strategy \( W_F \) (respectively, \( W_{NF} \)) of a firm denotes that this firm locates in country \( W \) and adopts the flexible technology (respectively, the non-flexible technology).

Given that \( CNF^{RD} > CNF \), no equilibrium arises where both firms locate in country \( W \) and adopt the non-flexible technology, nor where both firms choose to locate in country \( S \).

Moreover, \( L < L^{RD} \) and \( F < F^{RD} \) imply that there is no equilibrium where both the firms locate in country \( W \) and choose different technologies.

There are then three kinds of (location and technology) equilibria:

i) the equilibria are \((S, W_F)\) or \((W_F, S)\) \( \Leftrightarrow \ CNF^{RD} < F^{RD} \) and \( L^{RD} > CF \)
\[ \Leftrightarrow \frac{1}{36} (14 - 14t/a - 37t^2/a^2) \equiv f_3(t/a) < (\sigma^2_S + \sigma^2_W)/a^2 < \frac{1}{8} (2 - 2t/a + 37t^2/a^2) \equiv g(t/a). \]

In such equilibria, the firm located in country \( S \) earns a higher expected profit than its rival \( \Leftrightarrow L^{RD} > F^{RD} \Leftrightarrow (\sigma^2_S + \sigma^2_W)/a^2 < h(t/a) \), which is the same condition as in Section 2).

ii) the equilibrium is \((W_F, W_F)\) \( \Leftrightarrow L^{RD} < CF \Leftrightarrow g(t/a) < (\sigma^2_S + \sigma^2_W)/a^2. \)

iii) the equilibria are \((S, W_{NF})\) or \((W_{NF}, S)\) \( \Leftrightarrow CNF^{RD} > F^{RD} \) and \( L^{RD} > CF \)
\[ \Leftrightarrow f_3(t/a) > (\sigma^2_S + \sigma^2_W)/a^2 \text{ and } g(t/a) > (\sigma^2_S + \sigma^2_W)/a^2. \]

11 If \( f_3(t/a) > (\sigma^2_S + \sigma^2_W)/a^2 > g(t/a) \), there are three location equilibria: \((S, W_{NF})\), \((W_{NF}, S)\), and \((W_F, W_F)\), but \((W_F, W_F)\) pareto-dominates the other if and only if \((\sigma^2_S + \sigma^2_W)/a^2 > 4(t/a)^2\), as is the case in this zone.
Figure 3 maps these equilibria.

**Proposition 2** If weak EPL does not constraint the domestic firms’ technology,
- firms never agglomerate in country S,
- there arises a new dispersion equilibrium in which the firm located in country W adopts the non-flexible technology (zone 3 in figure 3).

3.2 Assuming some flexibility for firms located in country S

In Section 2, firms located in country S were assumed to have no volume flexibility and hence to be unable to get an informational benefit: these firms had to choose *ex ante* the quantities to sell on each market. This section relaxes this assumption in two ways: the first consists in introducing the option for these firms to allocate their production between the two markets; the second involves the possibility of an upward *ex post* adjustment for such firms.

3.2.1 Allocation flexibility

In this paragraph, firms located in country S are assumed to be able to choose *ex post* the allocation of their production between the two markets, although unable to adjust their global output volume.\(^{16}\)

It should be noted that such an allocation flexibility has no value for a perfectly flexible firm which is able to adjust *ex post* and costlessly the quantity it produces for each market.

Let us then consider that firms located in country S choose *ex post* the allocation of their output, the quantity of which has been chosen *ex ante*.

In any subgame following heterogenous locations, the firm located in country S (say, firm A) therefore chooses *ex ante* a total quantity and chooses *ex post* \(q_{SA}\) for market S and \(q_{WA}\) for market W under the constraint that \(q_{SA} + q_{WA} = q_A\), whereas the firm located in market W (say, firm B) chooses *ex post* \(q_{SB}\) for market S and \(q_{WB}\) for market W.

The equilibrium expected profits in this subgame are (see appendix 3):

\[
E\pi_A = \frac{(4a^2 - 4at + 9t^2)}{16} + \frac{(\sigma_S^2 + \sigma_W^2 - 2\rho \sigma_S \sigma_W)}{18} \equiv L^{AF} \\
E\pi_B = \frac{(4a^2 - 4at + 17t^2)}{32} + \frac{(13\sigma_S^2 + 13\sigma_W^2 + 10\rho \sigma_S \sigma_W)}{72} \equiv F^{AF}
\]

where \(\rho\) is the correlation coefficient.

In the subgame in which both firms are located in country S, the equilibrium expected profits are also modified to the extent that each firm chooses *ex ante* a total quantity to produce and *ex post* the allocation of this production between the two markets.

\(^{16}\)The absence of allocation flexibility in the basic model enables us to highlight that such a flexibility is not needed for the emergence of the dispersion equilibrium.
The equilibrium expected profits in this subgame are (see appendix 3):

$$E\pi_A = E\pi_B = CNF + (\sigma^2_S + \sigma^2_W - 2\rho\sigma_S\sigma_W)/18 \equiv CAF$$

Finally, the expected profit earned by the firms when both are located in country W are the same as in Section 2:

$$E\pi_A = E\pi_B = CF = \left[ a^2 + (a-t)^2 \right]/9 + (\sigma^2_S + \sigma^2_W)/9$$

The expected profits matrix available for the first stage decisions then becomes:

<table>
<thead>
<tr>
<th>firm A</th>
<th>S</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>CAF,CAF</td>
<td>L^{AF},F^{AF}</td>
</tr>
<tr>
<td>W</td>
<td>F^{AF},L^{AF}</td>
<td>CF,CF</td>
</tr>
</tbody>
</table>

A heterogenous location equilibrium emerges if and only if $L^{AF} > CF$ and $F^{AF} > CAF$ i.e. $\Rightarrow$

$$\frac{1}{36} (-28t/a + 28 - 121t^2/a^2) \equiv f_4(t/a) < (\sigma^2_S + \sigma^2_W + 2\rho\sigma_S\sigma_W)/a^2 < \frac{1}{8} (-4t/a + 4 + 65t^2/a^2) \equiv g_4(t/a)$$

In this equilibrium, the leader receives the highest expected profit $\Leftrightarrow \frac{1}{4} (2 - t/a)^2 \equiv h_4(t) > (\sigma^2_S + \sigma^2_W + 2\rho\sigma_S\sigma_W)/a^2$.

At every dispersion equilibrium, the output of the committed firm, $(a - t/2)$, is always higher than the expected quantity produced by its flexible competitor, $(a/2 - t/4)$.

Figure 4 maps the equilibria.

**Proposition 3** Allocation flexibility allows a committed firm to get an informational benefit which is decreasing with the correlation coefficient between demands. Thus, allocation flexibility enhances expected profits earned by committed firms (Stackelberg leader or non-flexible Cournot competitor) and reduces that of Stackelberg follower, compared with Section 2. This tends to make agglomeration in the country with the weakest EPL less likely to emerge.

### 3.2.2 Upward ex post adjustment

In Section 2, firms located in countries with strict EPL were assumed to have no scope for ex post adjustment.

Quantity commitment has a strategic value when firms cannot reduce their quantities ex post. Overtime and temporary work permits them to increase their productions ex post in exchange for an additional marginal cost. In comparison with Section 2, introducing this possibility favors locating in the country with the strictest employment protection and makes an agglomeration equilibrium in country W less likely.

Indeed, when firms are located in different countries, if the firm located in country S produced, in each market, the same quantity ex ante as in Section 2, it would increase ex post its production for the highest demand intercepts.
For these states of nature, it would then obtain an informational benefit (to the detriment of its perfectly flexible competitor) and receive more profit than in Section 2. The profit earned in the other states of nature would remain unchanged, so that the expected profit of firm $S$ would be higher than it was in Section 2.

As the firm in country $S$ chooses an optimal $ex\ ante$ quantity (which is lower than that in Section 2), its expected profit further increases. $L^{RD}$ is then higher than in Section 2.

On the other hand, the introduction of the possibility of a costly upward $ex\ post$ adjustment for firms in country $S$ does not change the expected profit realized when both firms are located in country $W$. $CF$ is then the same as it is in Section 2.

Therefore, $L^{RD} - CF$ is higher than it is in Section 2, that is, the Stackelberg leader has less incentive for deviating from the Stackelberg equilibrium.

**Proposition 4** The possibility of costly $ex\ post$ adjustment for a firm located in country $S$ makes an agglomeration equilibrium in country $W$ less likely.

### 3.3 Assuming price competition

Up until now, it has been assumed that firms were competing in quantities. Now suppose that they compete in prices in the second stage, with the EPL constraining the firms’ technologies and therefore the sequence of productions in the same way as in Section 2.

The usual result is that price competition is beneficial to the second-mover provided that prices are strategic complements, as is the case here. Price competition might then be expected to lead firms to locate in country $W$ in order to retain the capacity of adjustment (output flexibility). In fact, the second-mover has an advantage when there is a sequence in pricing. Here, prices are both chosen $ex\ post$, while quantities are chosen $ex\ ante$ or $ex\ post$, depending on the technologies. It follows that agglomeration in country $W$ can no longer emerge at equilibrium. To see that, it suffices to show that each firm prefers to locate in country $S$ when its competitor is in country $W$. Let us then determine the price equilibria (and the resulting expected profits), firstly, when both firms are located in country $W$, and secondly, when they are located in different countries.

If both firms are located in country $W$, their marginal cost in serving market $W$ (respectively, $S$) is equal to 0 (respectively, $t$). Firms being perfectly flexible, they engage in a price war on each market such that the unique equilibrium in each market is that which yields the Bertrand paradox. The equilibrium prices are then equal to 0 (respectively $t$) in market $W$ (respectively $S$) whatever the demand intercept. The equilibrium expected profit of each firm is then equal to 0 in each market.\(^{17}\)

\(^{17}\)Remember that, for expositional convenience, set-up costs have been neglected. If they were strictly positive, the expected profits to be taken into account would be negative. This would not alter the conclusion.
If firms are located in different countries, firm \( S \) has to sell the quantity chosen \textit{ex ante}. Following Gelman and Salop (1983), it can be shown that the firm located in country \( S \) - firm \( S \) - can set a price low enough that it leads the firm located in country \( W \) - firm \( W \) - to accommodate. But here, contrary to the Gelman Salop model, the firm located in country \( S \) is not committed in price, so, its best reply to the accomodation price of its rival is to undercut this price. Firms then engage in a price war.

In market \( W \), \( p_S \) - the firm \( S \)'s price - must be higher than \( t \) \( \forall q_S > 0 \). So, firm \( W \) will choose \( p_W = t - \xi \) (with \( \xi > 0 \) and \( \xi \to 0 \)). Then, demand to firm \( S \) is equal to zero \( \forall q_S > 0 \). Thus (on the condition that the neglected marginal cost of \textit{ex ante} production is replaced by a negligible strictly positive one, as is here assumed), the optimal \( q_S \) equals zero. This leaves firm \( B \) as a monopoly in market \( W \), allowing it to earn an expected profit equal to \( (a^2 + \sigma_W^2)/4 \).

In market \( S \), firm \( S \) seeks to sell the output which has been produced \textit{ex ante}. Given its cost advantage over its competitor and the volume flexibility available to the latter, firm \( S \) chooses \( p_S = t - \xi \) (with \( \xi > 0 \) and \( \xi \to 0 \)) (and \( p_S = t \) \( \forall q_S < a + \varepsilon_S - t \), and sells \( q_S \).

For \( q_S > a + \varepsilon_S - t \), firm \( S \) may choose either the price \( p_S^0 = a + \varepsilon_S - q_S \) which is the price enabling it to sell \( q_S \) when it is a monopoly, or the price \( t - \xi \) which results in selling only \( a + \varepsilon_S - t \) (the demand for this price). Assume for expositional convenience that \( t < (a + \varepsilon_S \text{ inf})/2 \). Then, the best price for firm \( S \) is \( t - \xi \).

These prices lead to \( q_W = 0 \). The expected profit earned by the (constrained) monopoly \( S \) in market \( S \) is then

\[
E_S = t \left( \int_{\varepsilon_0}^{\varepsilon_S \text{ sup}} (a + \varepsilon_S - t) f(\varepsilon_S) d\varepsilon_S + \int_{\varepsilon_0}^{\varepsilon_S \text{ sup}} q_S f(\varepsilon_S) d\varepsilon_S \right), \text{ with } \varepsilon_0 = q_S - a + t, \text{ and } f(\varepsilon_S) \text{ denoting the density function of } \varepsilon_S.
\]

The F.O.C. is

\[
\frac{\partial E_S}{\partial q_S} = \frac{\partial \varepsilon_S}{\partial q_S} + \frac{\partial E_S}{\partial \varepsilon_S} \frac{d\varepsilon_S}{dq_S} = 0 \Leftrightarrow \int_{\varepsilon_0}^{\varepsilon_S \text{ sup}} f(\varepsilon_S) d\varepsilon_S + (a + \varepsilon_0 - t - q_S) f(\varepsilon_S) = 0 \Leftrightarrow \int_{\varepsilon_0}^{\varepsilon_S \text{ sup}} f(\varepsilon_S) d\varepsilon_S = 0
\]

Thus \( \varepsilon_0 = \varepsilon_S \text{ sup} \), that is, \( q_S = a + \varepsilon_S \text{ sup} - t \).

The expected profit earned by firm \( S \) in market \( S \) is then equal to

\[
E_S = \int_{\varepsilon_S \text{ inf}}^{\varepsilon_S \text{ sup}} (a + \varepsilon_S - t) f(\varepsilon_S) d\varepsilon_S = (a - t)t,
\]

and the expected profit of firm \( W \) on this market is equal to 0.

So when firms are located in different countries, each of them earns a positive expected profit, which is higher than that obtained when both firms are

\footnote{If \( t \) was higher than \((a + \varepsilon_S \text{ inf})/2 \), for \( q_S > a + \varepsilon_S - t \), firm \( S \) would find it better to choose the price \( p_S^0 \) for some values of \( \varepsilon_S \). This would change the optimal value of \( q_S \), but not the fact that firm \( S \) earns a positive expected profit in market \( S \) in the dispersion configuration.}
located in country $W$. So, agglomeration in country $W$ cannot emerge under price competition.

**Proposition 5** If firms compete in prices instead of in quantities, they will never agglomerate in the country with the weakest EPL.

4 Conclusion

This paper analyzed the effect that different employment protection legislation regimes have on the location of oligopolistic firms facing fluctuating demands.

It yielded three main results.

First: that the country with the strongest EPL may attract firms (either in an agglomeration equilibrium, or in an asymmetric location equilibrium).

Second: that, when firms choose to locate in countries with EPLs of different strengths, the firm located in the country with the strongest EPL may earn a higher expected profit than its foreign competitor.

Third: that in every dispersion equilibrium, the output level – and thus the employment level – is always higher in the country with the strongest EPL.

Strategic considerations on the part of the firms play an important role in the differential in expected profits which exists in the dispersion equilibria as well as for the existence of such equilibria. As a general rule, it should be noted that everything which increases the differential in expected profits arising when firms are located in different countries, makes dispersion equilibria less likely to emerge.

All these results were obtained in an oligopolistic setting. As it is well established that international transactions (exports, FDI) are mainly due to a few large firms, such a framework seems to be appropriate. Moreover, it should be noted that the core problem addressed here is how EPL constrains the accommodation ability of firms facing a "permanent" demand uncertainty (a fluctuating demand), not their ability to adapt to new market conditions.

This model has not introduced a stage wherein countries can choose their EPL levels. The main reason for this is that the EPL level is chosen for the whole country: it applies to all industries, the oligopolistic as well as the more competitive, and to industries that are subject to a high level of demand uncertainty as well as those characterized by low uncertainty. Thus, the partial equilibrium framework adopted here does not allow for an examination of the choice of EPL; for the latter purpose a general equilibrium framework would be needed.

The present paper therefore does not result in recommendations in terms of economic policy; however, it does invite analysts and policy makers to also take into account the consequences which may arise from the oligopolistic nature of international competition.
5 Appendix 1: Quantity stage: Stackelberg and Cournot equilibria with (or without) asymmetric costs

Let \( \pi_i \) be the profit function of firm \( i \) in market \( k \), \( q_i \) (respectively \( q_j \)) firm \( i \)'s (respectively firm \( j \)'s) output, \( \varepsilon_k \) the demand intercept in market \( k \), \( c_i \) firm \( i \)'s marginal cost incurred in serving market \( k \) (including production cost and, when relevant, trade cost).

\[
\pi_i = (a + \varepsilon_k - c_i - q_i - q_j)q_i, j \neq i
\]

5.1 Cournot equilibrium

5.1.1 Flexible Cournot equilibrium

In the flexible Cournot equilibrium, firms choose their quantities \( \text{ex post} \) (i.e. after knowing \( \varepsilon_k \)) and simultaneously

\[
q_i = R_i(q_j) = \arg \max_{q_i} \pi_i = (a + \varepsilon_k - c_i - q_j)/2, j \neq i, \ i = 1, 2
\]

The equilibrium quantity of firm \( i \) is then:

\[
q_i = (a + \varepsilon_k - 2c_i + c_j)/3
\]

Its equilibrium expected profit is

\[
E(\pi_i) = (a - 2c_i + c_j)^2/9 + \sigma_k^2/9
\]

5.1.2 Non-flexible Cournot equilibrium

In the non-flexible Cournot equilibrium, firms choose their quantities \( \text{ex ante} \) (i.e. before knowing \( \varepsilon_k \)) and simultaneously.

Firm \( i \) maximizes its expected profit \( (E\pi_i = (a - c_i - q_i - q_j)q_i, j \neq i) \) given the output of firm \( j \).

\[
q_i = R_i(q_j) = \arg \max_{q_i} E\pi_i = (a - c_i - q_j)/2, j \neq i, \ i = 1, 2
\]

The equilibrium quantity of firm \( i \) is:

\[
q_i = (a - 2c_i + c_j)/3
\]

Its equilibrium expected profit is

\[
E(\pi_i) = (a - 2c_i + c_j)^2/9
\]
5.2 Stackelberg equilibrium

In the Stackelberg equilibrium, the leader is the non-flexible firm (say, firm A) and the follower is the flexible firm (say, firm B).

Firm B chooses its quantity \( q_B \) ex post (i.e. after knowing \( \varepsilon_k \)) given \( q_A \)

\[
q_B = R_B(q_A) = \arg \max_{q_B} \pi_B = (a + \varepsilon_k - c_B - q_A)/2
\]

Firm A anticipates this. Its profit is then:

\[
\pi_A = [a + \varepsilon_k - c_A - q_A - R_B(q_A)]q_A = \frac{1}{2} q_A (a + \varepsilon_k - 2c_A + c_B - q_A).
\]

As firm A cannot adjust its production ex post, it has to choose its output ex ante (i.e. before knowing \( \varepsilon_k \)).

Firm A’s output choice is then:

\[
q_A = \arg \max_{q_A} E \pi_A = (a + c_B - 2c_A)/2
\]

The follower’s equilibrium quantity is then

\[
q_B = R_B(q_A) = (a + 2\varepsilon_k + 2c_A - 3c_B)/4
\]

The equilibrium expected profits are:

\[
E(\pi_A) = (a + c_B - 2c_A)^2/8
\]
\[
E(\pi_B) = (a + 2c_A - 3c_B)^2/16 + \sigma_k^2/4
\]

5.3 Expected profit in the quantity stage equilibrium

Given the above calculations, and assuming that markets are segmented, that the marginal costs of producing are equal to 0, and that the unit cost for serving the foreign market is \( t \), the following expected profits are obtained in the quantity stage equilibrium, according to the firm’s competitive status (row) and the market (column):

<table>
<thead>
<tr>
<th>firm’s competitive status</th>
<th>home market</th>
<th>foreign market</th>
</tr>
</thead>
<tbody>
<tr>
<td>flexible Cournot competitor</td>
<td>( cf = (a)^2/9 + \sigma_k^2/9 )</td>
<td>( cf_t = (a - t)^2/9 + \sigma_k^2/9 )</td>
</tr>
<tr>
<td>non-flexible Cournot competitor</td>
<td>( cnf = (a)^2/9 )</td>
<td>( cnf_t = (a - t)^2/9 )</td>
</tr>
<tr>
<td>Stackelberg leader</td>
<td>( l = (a + t)^2/8 )</td>
<td>( l_t = (a - 2t)^2/8 )</td>
</tr>
<tr>
<td>Stackelberg follower</td>
<td>( f = (a + 2t)^2/16 + \sigma_k^2/4 )</td>
<td>( f_t = (a - 3t)^2/16 + \sigma_k^2/4 )</td>
</tr>
</tbody>
</table>
6 Appendix 2: Open-loop equilibria

Let us consider an open-loop assumption in each subgame where firms locate in different countries.

This assumption means that the firm moving ex ante chooses its quantity without being aware of the strategic effect that its commitment has on its flexible competitor’s output. That is, when there is a firm in each country, the firm located in country $S$ (say, firm $A$) chooses for market $k$ the quantity which maximizes the expected profit it earns in this market, without anticipating the reaction function of firm $B$.

\[ E\pi_A = E(a + \varepsilon_k - c_A - q_A - q_B)q_A = (a - c_A - q_A - E(q_B))q_A \]

\[ q_A = \arg\max E\pi_A = (a - c_A - E(q_B))/2 \]

For its part, firm $B$’s reaction function remains unchanged:

\[ q_B = R_B = (a + \varepsilon_k - c_B - q_A)/2 \]

so that

\[ E(q_B) = (a - c_B - q_A)/2 \]

So, in the quantity equilibrium, the outputs in market $k$ are $q_A = (a + c_B - 2c_A)/3$ and $q_B = (a + 3\varepsilon_k + 2c_A - 4c_B)/6$.

Expected profits earned in market $k$ are:
- for firm A: $(2a - 2c_A + c_B)^2/9$
- for firm B: $(a - 2c_B + c_A)^2/9 + \sigma_k^2/4$

Given the trade costs, the total expected profits earned in this subgame are:
- for the committed firm: $[(a + t)^2 + (a - 2t)^2]/9 = CNF^{RD}$,
- for the flexible firm: $[(a + t)^2 + (a - 2t)^2]/9 + (\sigma_S^2 + \sigma_W^2)/4 \equiv CF^{OL}$.

The matrix of expected profits available for the first stage decisions becomes:

<table>
<thead>
<tr>
<th>firm A</th>
<th>S</th>
<th>CNF, CNF</th>
<th>CNF^{RD}, CF^{OL}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>W</td>
<td>CF^{OL}, CNF^{RD}</td>
<td>CF, CF</td>
</tr>
</tbody>
</table>

As $CF^{OL} > CNF$, the location equilibria are:
- $(S, W)$ and $(W, S) \iff CNF^{RD} > CF \iff 4t^2 > (\sigma_S^2 + \sigma_W^2)$
- $(W, W)$ otherwise.

So, if the committed firm does not take into account the strategic effect of its quantity when choosing its output, the only equilibria which emerge are those where firms locate in different countries $\iff 4t^2 > (\sigma_S^2 + \sigma_W^2)$.

In such equilibria, the committed firm gets a lower expected profit than its flexible competitor ($CF^{OL} > CNF^{RD}$).
7 Appendix 3: Allocation flexibility and quantity stage equilibria

1- In a subgame following heterogenous locations, the firm located in country $S$ (say, firm $A$) therefore chooses ex ante a total quantity $q_A$ and ex post a quantity $q_{SA}$ for market $S$, and a quantity $q_{WA}$ for market $W$ under the constraint that $q_{SA} + q_{WA} = q_A$, whereas the firm located in market $W$ (say, firm $B$) chooses ex post $q_{SB}$ for market $S$ and $q_{WB}$ for market $W$.

The profit functions are then:

$$
\pi_A = (a+\varepsilon_S-q_{SA}-q_{SB})q_{SA} + (a+\varepsilon_W-t-(q_{A}-q_{SA})-q_{WB})(q_{A}-q_{SA})
$$
and

$$
\pi_B = (a+\varepsilon_S-t-q_{SA}-q_{SB})q_{SB} + (a+\varepsilon_W-(q_{A}-q_{SA})-q_{WB})q_{WB}
$$

The first order conditions for maximizing ex post profits are then:

- for firm $A$:

$$(a + \varepsilon_S - 2q_{SA} - q_{SB}) - (a + \varepsilon_W - t - 2(q_{A} - q_{SA}) - q_{WB}) = 0$$

- for firm $B$:

$$a + \varepsilon_S - t - q_{SA} - 2q_{SB} = 0$$

$$a + \varepsilon_W - (q_{A} - q_{SA}) - 2q_{WB} = 0$$

This yields the following ex post quantities:

$$q_{SA} = (\varepsilon_S - \varepsilon_W + 3t + 3q_A)/6$$
$$q_{SB} = (6a + 5\varepsilon_S + \varepsilon_W - 9t - 3q_A)/12$$
$$q_{WB} = (6a + \varepsilon_S + 5\varepsilon_W + 3t - 3q_A)/12$$

When choosing ex ante $q_A$, firm $A$ anticipates these quantities.

The quantity maximizing its expected profit is $q_A = a - t/2$.

This yields the following expected profits in the subgame equilibrium:

$$E\pi_A = (4a^2 - 4at + 9t^2)/16 + (\sigma_S^2 + \sigma_W^2 - 2\rho\sigma_S\sigma_{WS})/18 \equiv L_A^F$$
$$E\pi_B = (4a^2 - 4at + 17t^2)/32 + (13\sigma_S^2 + 13\sigma_W^2 + 10\rho\sigma_S\sigma_{WS})/72 \equiv F_A^F$$

where $\rho$ is the correlation coefficient.

2- In the subgame in which both firms are in country $S$, the equilibrium expected profits are also modified to the extent that each firm chooses ex ante a total quantity to produce and ex post the allocation of this production between the two markets.

Given this, and given the transport costs, profits can be written as:

$$\pi_A = (a+\varepsilon_S-q_{SA}-q_{SB})q_{SA} + (a+\varepsilon_W-t-(q_{A}-q_{SA})-(q_{B}-q_{SB}))(q_{A}-q_{SA})$$
and

$$\pi_B = (a+\varepsilon_S-q_{SA}-q_{SB})q_{SB} + (a+\varepsilon_W-t-(q_{A}-q_{SA})-(q_{B}-q_{SB}))(q_{B}-q_{SB})$$

The first order conditions for maximizing ex post profits are then:
- for firm A:
\[(a + \varepsilon_S - 2q_{SA} - q_{SB}) - (a + \varepsilon_W - t - 2(q_A - q_{SA}) - (q_B - q_{SB})) = 0\]

- for firm B:
\[(a + \varepsilon_S - q_{SA} - 2q_{SB}) - (a + \varepsilon_W - t - (q_A - q_{SA}) - 2(q_B - q_{SB})) = 0\]

This yields the following \textit{ex post} quantities in market S:
\[q_{SA} = (\varepsilon_S - \varepsilon_W + t + 3q_A)/6, \quad q_{SB} = (\varepsilon_S - \varepsilon_W + t + 3q_B)/6\]

Firms choose simultaneously the quantities, \(q_A\) and \(q_B\), which maximize their expected profits.
These optimal quantities are \(q_A = \frac{2}{3}a - \frac{1}{3}t\) and \(q_B = \frac{2}{3}a - \frac{1}{3}t\):
The equilibrium expected profits are:
\[E\pi_A = E\pi_B = (2a^2 - 2at + t^2)/9 + (\sigma_S^2 + \sigma_W^2 - 2\rho\sigma_S\sigma_W)/18 \equiv CAF\]

8 References


9 Figures

**Figure 1:**
location equilibria in the basic model

**Figure 2:**
open loop location equilibria