Divide and Rule: Geographical Diversification and the Multinational Firm

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Abstract

We develop a model to illustrate a motive for FDI that derives from a firm's overall locational strategy. A firm, that initially has a plant in its home country, may choose to also have a foreign plant in order to improve its bargaining position versus local labour unions. This permits the firm to reduce wages. Furthermore, the existence of a second foreign plant acts to discipline the demands of foreign workers. Thus, the firm is faced with a link between the wage and its degree of geographical diversification. This drives up the number of plants the firm has in equilibrium.

The study of foreign direct investment (FDI) has tended to focus upon two reasons for locating in a particular country. First, firms are motivated by the search for lower costs of supplying a market. Second, firms may wish to gain improved access to that country's or some other country's market.[1] If attention is restricted to these two motives, then a firm that considers having similar production facilities in more than one foreign country should be regarded as facing a number of separate FDI decisions. Writers such as de Meza and Van der Ploeg (1987) and Sung and Lapan (2000) have shown, using models with location-specific uncertainty, how a firm's FDI decisions can instead be regarded as together determining that firm's overall *locational*

strategy. This alternative approach complements standard explanations of FDI by highlighting a possible motive for FDI that derives from FDI's role in determining the geographical diversification of a firm. We show that even without uncertainty, but in the presence of labour unions, there can be a motive for FDI that derives from a firm's overall locational strategy. Furthermore, such FDI acts to set up similar production capabilities in a number of countries.

Briefly put, the idea is this: a firm may choose to have foreign production in order to improve its bargaining position versus local labour unions, and so secure lower wages than if they remained domestic. Furthermore, choosing to have a plant in more than one foreign country may lower wages further. Thus, the firm is faced with a potential link between the wage rate and its degree of geographical diversification. Specifically, the *greater* is the firm's geographical diversification (i.e., the more countries in which it has a plant) the *lower* might wages be.

Leading firms are typically highly geographically diversified. For example, leading EU firms will most often have operations in more than two or three EU countries. It is most relevant to focus upon within-industry geographical diversification: if an EU-owned firm has a foreign plant in an EU country, in how many other EU countries is the firm active in the same industry? A recent study by Pavelin (2000) shows that leading EU firms are on average active in three other EU countries.[2] Indeed, a foreign plant in the larger EU countries, such as UK, Germany and France, will on average be accompanied by similar operations by the same firm in four other EU countries; for the smaller EU countries, such as Ireland, Portugal and Greece, the figure is around six. Such a pattern of foreign production might arise from a succession of entirely separate FDI decisions. Instead, we aim here to investigate one potential motive for FDI that arises out of a firm's desire to adopt its optimal degree of geographical diversification.

The idea that a firm may, by being multinational, improve its bargaining position versus workers, is one that has been subject to informal discussion in the theory of the multinational enterprise (see for example Cowling and Sugden (1987)).[3] It is argued that an MNE can use a threat to shift production away from a particular site to influence its relations with unions in each country in which it produces. This ensures that the unions compete among themselves for employment within the firm. Such competition bids down wages below those available to a uninational firm. The firm's status as a multinational is crucial, as it makes credible[4] the threat to shift production away from each country.

This informal story was brought within a formal framework by Huizinga (1990). Huizinga provides a treatment that is explicitly concerned with geographical diversification.[5] He modelled a firm that must decide upon the number of geographically differentiated plants it will have. Each plant earns rents according to the transport cost saving it offers the firm. These rents are then partially

appropriated by a plant-specific union. Thus, the plant-specific rents and wages are both decreasing in the number of plants. He shows that: if labour demand at each plant is more elastic the greater is the number of plants, the wage will be decreasing in the number of plants such that the firm will be motivated to have more plants than is technologically efficient.[6] Geographical diversification is driven up by a desire to reduce wages.

Huizinga assumes that more plants means stronger competition between unions for employment within the firm, as witnessed by more elastic labour demand. This assumption ensures the firm will become more geographically diversified than is technologically efficient. However, he does not model the mechanism by which increased geographical diversification improves the bargaining position of the firm. It is altogether possible that extra plants could drive down plant-specific rents and wages in the same proportion. In that case, wages would be set such that the firm would not drive up its profits by building more plants than is technologically efficient.

By contrast, we treat the issue using a simple game-theoretic approach. We present a model of a firm's decision regarding the number of plants to have, where competition between workers for employment within the firm is explicitly described. Where the firm has more than one location, each plant-specific union will set its wage bearing in mind that too high a wage will cause the firm to produce elsewhere. We show that a firm that geographically diversifies can, by doing so, drive down its production costs. This is because the diversification brings international competition between labour unions.

The work of Horn and Wolinsky (1988) is related to our paper. Building on the Rubinstein (1982) bargaining model they consider two groups of workers employed in a single firm. A major result in their paper is that if the two groups of workers are sufficiently close substitutes it is an equilibrium that they unite in an encompassing union. If they are complements then they are better able to advance their interests in separate unions. Horn and Wolinsky briefly discuss how their results suggest an extension to an FDI setting. They mention the possible incentive of firms to set up plants in different countries to weaken the bargaining position of workers that cannot organise internationally. Skaksen and Sørensen (2001) develop this and exploit the mechanisms in Horn and Wolinsky in a two country, one firm FDI model. They find that if there is a high degree of complementarity between activities moved abroad and those remaining at home then the workers in the home firm benefit from FDI. In our model, using the terminology of Horn and Wolinsky, workers in the different plants of the multinational are substitutes and hence their interests are radically opposed. We present a three country model in which the motive for FDI is to weaken the power of unions. We examine the link between this divide and rule motive for FDI and geographical diversification of plant location and production. The main parameters we focus upon are FDI costs, trade costs and the reservation wages of workers in different locations.

1. The model

There is one firm, a monopolist in the production of a single good. There are three countries: A, B and C. Each country is a potential production location for the firm, but only A hosts a market for the good. The market in A is such that the inverse demand function is:

$$p = \alpha - \beta q \tag{1}$$

where q is the firm's output. Initially, the firm has a plant in A, and must choose whether or not to set up foreign plants in either B or C, or both.[7] There is a fixed cost of setting up a plant, G. Once plant-specific costs are sunk, technology is such that the production of each unit requires one unit of labour. Thus, there is a constant marginal cost equal to the wage rate. Any goods produced overseas must be transported back to A to be brought to market. There is a constant per-unit transport cost of t.

Plant-specific labour unions set wages. Thus, wages are set at the plant-level by a different monopoly union at each plant. So, one assumption here is that there is no international cooperation between unions.[8] The reservation wage (the minimum wage for which labour can be hired) differs between countries: ω_A in A, ω_B in B, and ω_C in C. We assume that the foreign countries offer lower reservation wages than does A, i.e. $\omega_A > \omega_B, \omega_C$.

There is a three stage game as follows: in the first stage, the firm decides whether to build a plant in B, C or both; in the second stage, local unions set wages at each plant; in the third stage, the firm sets output at each plant. So, foreign direct investment is taken to be fixed when unions set wages. It also follows that both FDI and wages are taken to be fixed when the firm sets output.

It is worth making two further points before presenting results. These concern the scope of the model. Firstly, the foreign production permitted is purely vertical in nature: the firms' foreign production is used only to serve the domestic market. Thus, it is of the sort that replaces high cost domestic production with low cost foreign production, without seeking to gain entry into the foreign market, i.e., that typically associated with north-south or west-east FDI. In the context of EU firms, prime examples would be their FDI into China and Eastern Europe.

Secondly, despite the simple and abstract nature of this model, it is general in one respect. The use of a three country world is not as restrictive as it may seem. Given the other features of the model, only two foreign countries would ever be important for the analysis—these being the two countries with the lowest reservation wages. Thus, the model represents a case where there are at least two foreign countries that offer lower reservation wages than the home country. There may be more than two, but B and C are the two that offer the lowest.

The next section gives results. Some concluding remarks are provided in Section 3.

2.   Results

The game is solved by working backwards. The equilibrium output level is dependent upon wages and the firm's FDI strategy. Irrespective of the number of plants it has, the firm will chose to produce in only one location. This is because each plant it has is capable of serving the entire market at constant returns to scale. Thus, even if the firm has more than one plant, one of the plants will offer the low cost method of serving the market. All production will take place at this plant and the others will lie dormant. Output will be set at the monopoly level given the marginal costs of production and transportation associated with the working plant.

It would be somewhat unrealistic to assert that a dormant plant, or dormant plants, characterise FDI. It reflects the simple and abstract nature of the model we present. It would be more realistic to have a multi-plant firm produce in all plants and shift production only partially to favour lower cost plants. Indeed, a model made more sophisticated by the suitable introduction of geographically differentiated products, or plant-level decreasing returns to scale, would give more realistic outcomes of this type. However, such sophistication would leave the central point of the paper, to illustrate FDI motivated by a desire to influence wage-setting behaviour, unchanged.

The wage set by the union at each plant is determined by the reservation wages in the countries where the firm has a plant, and the pattern of FDI. If the firm remains uninational, the monopoly union sets the wage[9] as follows:

$$w_A = \frac{\alpha + \omega_A}{2} \tag{2}$$

where w_A is the wage set by the union in A. If instead the firm has a foreign plant in B, C or both, the unions compete to ensure that the firm produces at their plant. They set wages at the highest level that will nonetheless attract production, subject to the restriction that wages be no lower than the reservation wage. The attractiveness of a foreign plant is handicapped by the costs of shipping the goods back home. So to be successful, a foreign union must set a wage of no more than the wage set in A less t. Similarly, the union at home must not set a wage in excess of the sum of t and the lowest wage set abroad. In equilibrium the unions will set wages as follows (where ϵ is the small amount by which the successful plant undercuts its nearest rival):

One foreign plant (in $i = $ B or C)

$$w_A = \max(\omega_A, \omega_i + t - \epsilon) \tag{3}$$
$$w_i = \max(\omega_i, \omega_A - t - \epsilon) \tag{4}$$

Two foreign plants

$$w_A = \max(\omega_A, \min(\omega_B + t - \epsilon, \omega_C + t - \epsilon)) \tag{5}$$

$$w_B = \max(\omega_B, \min(\omega_A - t - \epsilon, \omega_C - \epsilon)) \tag{6}$$

$$w_C = \max(\omega_C, \min(\omega_A - t - \epsilon, \omega_B - \epsilon)). \tag{7}$$

This brings us to the FDI choice. There are four possible configurations of FDI: no FDI, FDI in only B, FDI in only C, FDI in B and C. These will be referred to as OO, FO, OF and FF, respectively. The location of production will be indicated by a subscript, e.g., OO_A refers to domestic production by a uni-national firm; OF_C is foreign production located in a plant in C; FF_B refers to a three-country firm that produces in B. We will present the range of equilibrium outcomes graphically. First, by way of introduction, consider three exhaustive cases: (i) ω_A is below $\omega_B + t$ and $\omega_C + t$; (ii) $\omega_A - t$ lies between the reservation wages in the foreign countries; and (iii) in which ω_A is above $\omega_B + t$ and $\omega_C + t$. Without loss of generality, let us assume for the moment that $\omega_B < \omega_C$.

In case (i), production will take place in A even if there is FDI. This is because workers in A will, if faced with competition from abroad, offer the lowest marginal cost of serving the market: $\omega_B + t - \epsilon$. Thus, the firm faces the following choice: remain domestic and so pay a monopoly wage; or set up a plant in B and so introduce the international competition between workers that drives down domestic wages. Note that there is no incentive to set up a second foreign plant. The three-plant firm would still produce in A, where wages would be set to undercut the lowest cost foreign plant. So, building a plant in the foreign country with the lowest reservation wage succeeds in reducing the domestic wage to the lowest level available to the firm. Therefore, the relevant choice for the firm is between OO_A and FO_A, and depends upon the size of the cost of FDI, G.

In case (ii), as in case (i), there will be FDI in one country at most. If there is FDI into country B then production will take place there and the marginal cost of serving the domestic market will be $\omega_A - \epsilon$, as $w_B = \omega_A - t - \epsilon$. The firm faces a choice between OO_A and FO_B.

Finally, in case (iii) the firm may choose to build two foreign plants. With plants in only A and B production takes place in B at wages determined by the reservation level in A ($\omega_A - t - \epsilon$). However, with three plants production again takes place abroad, but at a lower wage: one determined by the reservation wage in C ($\omega_C - \epsilon$). The firm must choose between OO_A, FF_B and FO_B or OF_C. It is worth noting that if the firm opts for two plants it is indifferent between B and C as a destination for its FDI. The explanation for this somewhat surprising result is that regardless of which foreign location the firm chooses, production takes place at that location, at a wage equal to $\omega_A - t - \epsilon$.[10]

The results are presented for four different levels of the plant-specific cost, G.[11] At higher levels of G, FDI is less attractive as the fixed cost of a foreign plant is greater. So, we expect and see more widespread FDI as we move from Figure 1, through 2 and 3, to Figure 4. To aid understanding of the figures we will describe the key features of one of them. The workings of the other figures should then be clear. We will focus on Figure 4 in which the FDI cost is very low

and FDI will occur in all the areas of the figure. Consider first the two regions marked 'OF$_A$' and 'FO$_A$' in the north east of the figure, where both ω_B and ω_C are above $\omega_A - t$. Here the firm invests in one country: in B when $\omega_B < \omega_C$ (to the left of the diagonal line); in C when $\omega_C < \omega_B$. In either case, the firm produces in A. The wage in A is set so that $w_A - t$ marginally undercuts the reservation wage of the country they invest in. In the area marked 'OF$_C$' ω_C is low but ω_B is high ($\omega_C < \omega_A - t < \omega_B$). In this region the firm simply invests and produces in C at a wage $w_C = \omega_A - t - \epsilon$. The area marked 'FO$_B$' is the mirror image of the OF$_C$ region. In 'FO$_B$', a low reservation wage in B brings investment, and production, in B. Next consider the central region marked 'FO$_B$ or OF$_C$'. Here both ω_B and ω_C are lower than $\omega_A - t$. In this region, as explained earlier, the firm is indifferent between investment in B or C because regardless of which foreign location the firm chooses, production takes place at that location, at a wage equal to $\omega_A - t - \epsilon$. In this region the firm is not concerned about the ranking of ω_B and ω_C, only that they are lower than $\omega_A - t$. In the regions marked 'FF$_B$' and 'FF$_B$' *both* foreign reservation wages are low enough for the firm to find it optimal to set up a plant in both foreign locations. It will then produce in the lower reservation wage country at a wage set just below that in the higher reservation foreign country. Thus in the south west of Figure 4 we have two regions separated by the diagonal line. Above the diagonal, we have $\omega_C < \omega_B$ and so production occurs in C; below the diagonal, production is in B.

Also looking at Figures 1 to 4, note that in each of the figures, FDI is more advantageous close to the axes, as this is where overseas reservation wages are at their lowest. Indeed, this is reflected in the results, where in Figure 2, non-FDI outcomes are restricted to only the north-east corner of the diagram. The crucial features of these results for our purposes relate to the motive for FDI that is derived from the firm's ability to influence wage-setting. It is upon this that we will focus our attention.

2.1. The link between geographical diversification and wages

The firm can, by building a foreign plant, drive down the wage set by the union in its home country. The existence of a foreign plant acts to discipline the demands of domestic workers. In the absence of a foreign plant, the domestic union would set a monopoly wage; if it faces an MNE it sets a wage at the home reservation wage or slightly below the cost of serving the market from abroad. So, if at least one of the foreign countries offer a low cost environment, and G is sufficiently low, the firm will build a foreign plant in order to lower wages. Indeed, the firm may even continue to produce at home (this is OF$_A$ and FO$_A$ in Figures 2, 3 and 4). In this case, the only role of the foreign plant is to bid down domestic wages.

Similarly, by building two foreign plants (this is FF$_B$ and FF$_C$ in Figure 4), the firm can drive down the wage set by foreign unions. In this case, the existence of a second foreign plant acts to discipline the demands of foreign workers. In the absence of a second foreign plant, a foreign union would set a wage so

as to slightly undercut the firm's costs at home; if two foreign unions compete, they set wages to undercut each other. So, if both foreign countries offer a low cost environment, and G is sufficiently low, the firm will build two foreign plants in order to lower wages. The firm will only produce in one of them, the role of the other foreign plant is to bid down the wages set at the working plant.

2.2. Comparisons with a base case

The set of diagrams given above show not only the equilibrium outcomes in the full model, but also those for a restricted model: one where the wage in each country is set at the reservation wage. This restriction is imposed in order to show a pattern in FDI that occurs when there is no link between the firm's geographical diversification and wage-setting behaviour in each country. In the base case, wages are set in each location at the reservation wage. Thus a necessary, but not sufficient, condition for FDI is that the reservation wage at the foreign location be strictly less than $w_A - t$. The firm faces a standard FDI trade-off between lower variable costs and higher fixed costs—undertaking FDI only if the foreign wage represents a saving that is sufficient to recoup the cost of the plant. Figures 5 to 8 facilitate comparisons between the base case and the full model at the same levels of G. The range of G of Figure 8 corresponds to that of Figure 4, while that of Figure 7 corresponds to that of Figure 3, etc. Again, to aid understanding of the figures, we will describe one of them (Figure 8) in detail and show how it differs from the corresponding figure for the full model (Figure 4). In Figure 8, OO_A (no FDI) occurs at all foreign reservation wages above $w_A - t$, and even some below. In contrast, in Figure 4 there is FDI at some foreign reservation wages above $w_A - t$. This is because, in the full model, the firm can lower the wage it faces at home by engaging in FDI to generate competition between unions. Figure 4 also shows the firm making investments into both B and C that together engender competition between the foreign unions. However, in Figure 8 there is FDI into at most one foreign country, because in the base case there is no strategic advantage to the firm in holding excess capacity. This and other pairwise comparisons of the figures reveal that, at the same level of G, FDI is more widespread in the full model.

This is perhaps a little surprising because marginal costs are weakly lower in the base case; reservation wages are, by definition, the lowest labour costs that the firm can face in each country. The incentive to undertake FDI is greater the lower are variable costs. This is because lower variable costs mean a larger output, and FDI involves a fixed cost (G) in exchange for a per-unit saving (the wage differential minus t). So from this, one would expect a greater prevalence of FDI in the base case. However, there is more FDI in the full model. This is because the motive for FDI that the firm derives from its ability to influence wage-setting outweighs the weakly higher wages it faces in all countries in the full model.
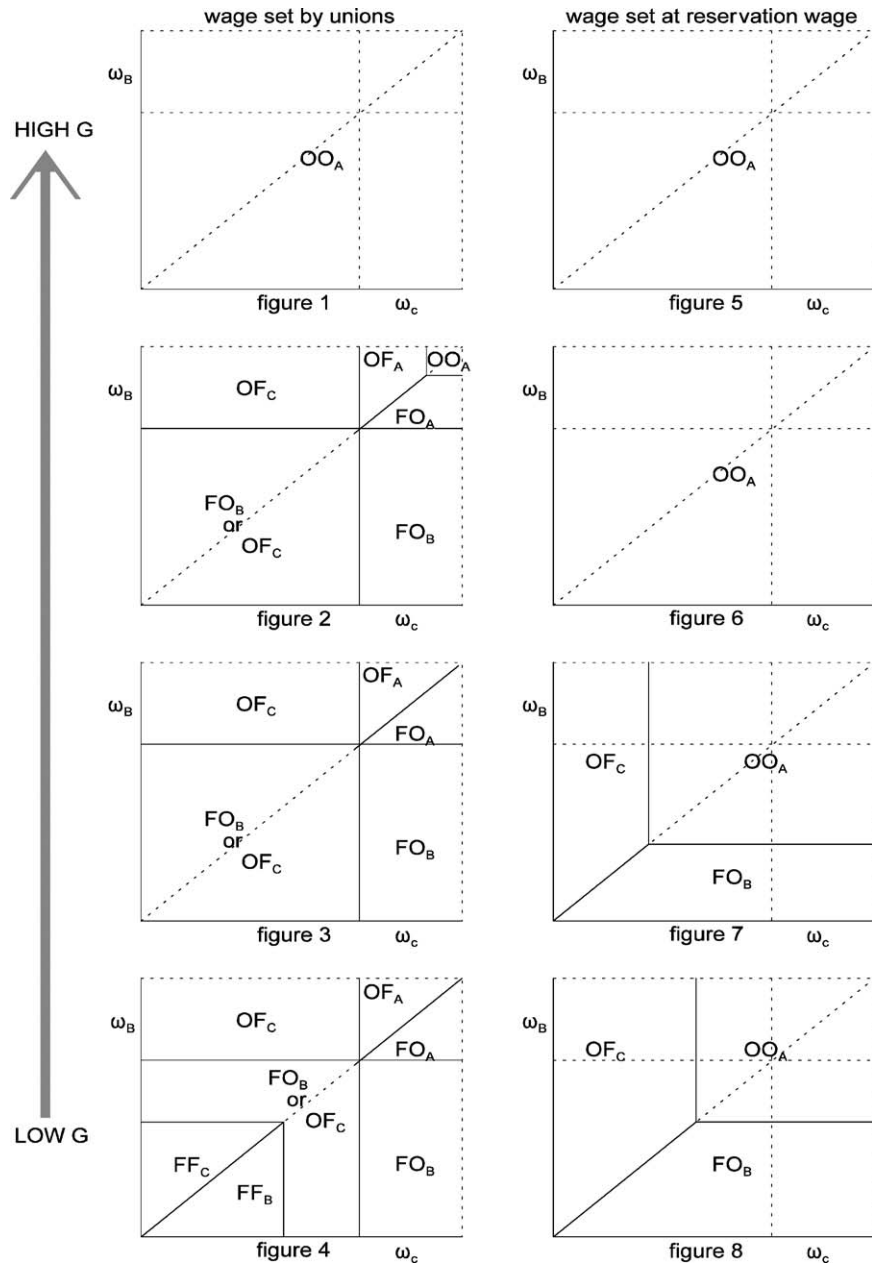
Figures 1–8.   At each level of G, there is more FDI when wages are set by unions. (In the figures the upper bound on ω_B and ω_C is at ω_A; and in Figures 2–4 the intermediate level $\omega_A - t$ is the upper bound on the region marked 'FO$_B$ or OF$_C$).

2.3. *Trade liberalisation*

It is interesting to consider the relationship between trade liberalisation and FDI in our model. Lower trade costs (t) harden the wage competition that the domestic union faces if the firm has a foreign plant, which increases the incentive to engage in FDI. Consider the choice between not investing (OO_A) and investing in one foreign country while continuing to produce at home (FO_A or OF_A). In OO_A production costs are of course independent of t. If the firm were instead to choose FO_A (OF_A), the marginal cost would be $w_A = \omega_B - \epsilon + t$ ($w_A = \omega_C - \epsilon + t$), which depends positively on t. Hence a fall in trade costs increases the incentive to engage in this form of strategic FDI.

It is also the case that a reduction in trade costs increases the incentive to produce in foreign plants. When a firm has one foreign plant, for instance in B, the marginal cost of supplying the home market is $\max(\omega_B + t - \epsilon, \omega_A)$ were it served from the home plant, and $\max(\omega_A - \epsilon, \omega_B + t)$ were it served from abroad. Thus the lower is t, the more likely it is that the marginal cost at home is ω_A. If this is the case, the foreign plant offers the lowest cost method of serving the market ($\omega_A - \varepsilon$), and production will be located there.

Next consider the impact of trade liberalisation on the choice between investing in one location versus investing in two locations, e.g., FO_B versus FF_B. At FO_B, the cost of serving the home market is independent of t as it is determined by the reservation wage in the home country (as $w_B + t = \omega_A - \varepsilon$). However, in the FF_B regime the cost of serving the domestic market is increasing in t (as $w_B + t = \omega_C + t - \varepsilon$). Hence, a fall in trade costs increases the incentive to set up two plants.

3. Conclusion

This simple model is a formal illustration of an idea that is likely to be familiar to the reader: firms can improve their bargaining position versus local labour unions by being multinational. We show a mechanism by which a link between geographical diversification and wage-setting can exist. Furthermore, we show the effect of such a link on the FDI behaviour of a firm: FDI is made more widespread. This is because having one foreign plant may drive down wages, and having two may drive them down further still.

We assumed throughout that unions could not cooperate internationally. The absence of international cooperation was taken as a stylised fact. While cultural and linguistic impediments to international cooperation have proved, and continue to prove, prohibitive, deepening globalisation of the business environment may facilitate international relationships of this kind. If such cooperation were to occur, it would act to frustrate attempts, on the part of global business, to divide and rule.

Notes

1. Buckley and Casson (1981) specify the optimal timing of FDI for a single firm by reference to costs, demands and market growth. The relationship between production costs, market access and strategic behaviour in determining FDI is modelled by Smith (1987), Horstman and Markusen (1987) and (1992) and by Motta (1992). Caves (1996) presents an excellent discussion of such standard explanations of multinational enterprises and FDI.
2. Pavelin uses the NACE three-digit classification to define industries.
3. Somewhat related to this is the advantage to a firm of commitment to investment before unions choose wages. Van der Ploeg (1987) shows that such commitment can reduce the ability of unions to extract rent. For a review of how the theory of the MNE has addressed these issues, see Caves (1996).
4. It is made credible in that such a multi-plant firm can reduce its production at one location while maintaining overall output, and without incurring the large fixed costs of building a new plant. It can do so by increasing production at its other plant or plants. They can, of course, only do so if there is initially sufficient excess capacity at the alternative site(s). The implicit assumption is that workers will only believe that production may be allocated elsewhere once capacity exists elsewhere.
5. There is also a growing literature on wage bargaining and FDI that is not concerned with geographical diversification. See for instance, Naylor and Santoni (2003) and Zhao (1998).
6. He defines the technologically efficient number of plants as that which the firm would choose to have given a non-unionised workforce. If workers do not bargain collectively, the firm will not reduce wages by increasing the number of plants. This is because the workers would not receive a wage determined by rents accrued at each plant.
7. The firm will wish to have at most one plant in any country. This is because each plant offers enough capacity to serve the entire market, and because there is only one union in each country. Indeed, it is worth noting that in this model a country can therefore be interpreted as a region defined as the geographical influence of a union.
8. We assume that workers cannot organise internationally and that unions cannot cooperate across national boundaries. There are cultural and linguistic reasons why unionisation is more difficult across, rather than within, national boundaries. If, in our model, international cooperation between unions were possible, geographical diversification of the firm would not achieve wage competition among its workers. For example, if one were to assume that side payments between unions were infeasible, and that the firm would, if all plants offered them the same cost of supplying the market, share production evenly between them, then international cooperation between unions would ensure that such international cost parity exists. A forward-looking firm would anticipate this and realise that opening extra plants would fail to introduce wage competition.
9. Here, the monopoly union unilaterally sets the wage so as to maximise labour rents subject to the firm's labour demand curve $q = (\alpha - w)/2\beta$. Extension to a Nash bargaining set-up would complicate the algebra without making any qualitative difference to the results. This is to say, it would not remove the potential for the type of motive for FDI that is the central focus of the paper. However, this is not to say that a change in the bargaining power of unions would have no effect on outcomes. If the bargaining power of the union in country A were reduced for any reason, perhaps through legislation, this would tend to depress both the wage set in A in the absence of FDI, and the firm's incentive to engage in FDI. Hence, there is a role for labour market policy in the 'anchorage' of domestic firms and jobs
10. It should be noted that the foreign unions are not indifferent between the two possible locations for FDI, as each would strictly prefer the firm to invest in their country. In particular, the foreign union with the lowest reservation wage would like, in order to secure inward investment, to offer a lower wage than the other. They do not do so because they cannot, in our model, credibly commit to such a wage prior to the firm's location decision. Once FDI has been carried out, the foreign union has an incentive to offer the lowest possible wage reduction that

        nevertheless undercuts the home union. It is the firm's anticipation of such an incentive that makes it indifferent between investing in B and C.

11. The four ranges of G allow us to depict all the qualitatively different cases. They are chosen as follows: In Figure 1, G is so high that it is never profitable to build a foreign plant. In Figure 2, G is high enough to ensure that it is optimal for the firm to do no FDI at some, but not all, ω_B, $\omega_C < \omega_A$. It is also too high for the firm to find it optimal ever to open two plants In Figure 3, the G is still too high to justify three plants, but low enough to ensure FDI into one location at all ω_B, $\omega_C < \omega_A$. In Figure 4, G is so small that investment in two plants will occur provided ω_B and ω_C are sufficiently low. Figures 5–8 show representative equilibrium outcomes for the base case using the same ranges of G as in the Figures 1–4. Thus the G in Figure 5 is same as that in Figure 1 and the G in Figure 6 is the same as that in Gigure 2 and so on for Figures 7 and 8.

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