Government policy towards FDI in the presence of network effects

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ABSTRACT

Greaney (2002) introduces the notion of "network effects" as an explanation for asymmetric trade and FDI outcomes. Acknowledging the existing literature linking business and social networks to trade, Greaney claims that her paper is the first to consider how networks affect FDI. Network effects are modelled as a cost disadvantage facing foreign firms trying to sell into a market. Greaney states that "the added cost may reflect search costs involved in locating buyers, distribution costs and/or information costs that are assumed to be higher for "outsiders" in some markets". The homogenous good approach adopted here still allows network effects to lead to asymmetric trade and FDI outcomes, while also allowing a new dimension to be added to the model in the form of government policy. The effect of policy on equilibrium outcomes and subsequent national welfare is examined.

J.E.L. Classifications: F12, F23, L52.

1. Introduction

Multinational Enterprises (MNEs) account for roughly 10% of global GDP and over one third of global exports.[1] Thus the study of their behaviour and their inclusion in models attempting to explain global trade flows is vital. Considering that these MNEs are usually large firms with market power, oligopoly is often the most suitable modelling strategy to adopt when dealing with them.

Greaney (2002) introduces the notion of "network effects" as an explanation for asymmetric trade and FDI outcomes, also referred to as trade or FDI friction. She specifically mentions the US-Japan bilateral trade (and investment) deficit, particularly in areas such as automobiles, as evidence of this bilateral trade and FDI friction. The previous literature on business and social networks, which includes, *inter alia*, Casella and Rauch (2002), Spencer and Qiu (2001), McLaren (1999), and Rauch (1996), deals specifically with the link between networks and international trade. Greaney claims that her paper is the first to consider how networks affect FDI. Of the above-mentioned papers, Spencer and Qiu (2001) is the most relevant to Greaney's paper in that it deals with the US-Japan trade friction induced by Japanese firms' vertical relationships known as *keiretsu*. The majority of the remaining literature deals with the effect of overseas networks of a certain nationality on trade. This "emigrant effect" on trade is not the focus of this or Greaney's paper. Rather the networks defined here are domestic networks that create artificial barriers for foreign business attempting to sell into the country, as explained below.

Networks can be defined as business and social networks in a given country which lead to firms native to that country having a cost advantage in serving that market. These networks may make entry into the local market difficult for overseas firms, regardless of whether they enter through export or FDI. The cost advantage to local firms thus leads to asymmetric trade and investment. Greaney models it as a cost disadvantage facing firms trying to sell into the market of the country with the network effects. Greaney states that "the added cost may reflect search costs involved in locating buyers, distribution costs and/or information costs that are assumed to be

[1] UNCTAD - World Investment Report 2007.

higher for “outsiders” in some markets”. Examples of networks often studied in the literature are the Japanese *keiretsu* and overseas Chinese networks (as in Rauch and Tirade (2002)).

I follow the method of Greaney in specifying four possible equilibria with different combinations of multinational and national firm activity in a two-country, two-firm, partial equilibrium duopoly model with homogenous goods. The firms compete on quantities a la Cournot. The two countries are considered identical in their wage and cost levels, and similarly-endowed in labour, capital, knowledge, technology etc. This assumption ensures that it is “North-North” (or “South-South”) trade and FDI that is being modelled here. This is not a model in which multinationals from the rich North engage in “factor-seeking” FDI in the South in order to cut costs. If FDI exists in this model it is “market-seeking” or horizontal FDI, in which the firm does not invest abroad to cut costs, but rather to serve similar markets from close proximity. Despite the undoubted increase in North-South FDI, and the possible positive implications for economic development, it must still be acknowledged that the bulk of global FDI is not of the North-South form. Blonigen (2005), using 1999 BEA data on US affiliate sales, shows that 67% of these sales are in the host country of the affiliate, which gives an indication of the importance of “market-seeking” FDI in total FDI from rich countries. Reinforcing the fact that the US figures are a good indicator for North FDI activity,, UNCTAD’s *World Investment Report 2007* records developed countries as accounting for 84% of global FDI outflows and 66% of global FDI inflows. Of FDI coming from developing countries (or the South), over 90% is invested in the same group of countries.[2] While accounting for a relatively insignificant proportion of global trade[3], the fact that the majority of global FDI flows between similarly-endowed countries is reinforced.

In serving the overseas market, the standard proximity-concentration trade-off is at play. The firm can either sell through export from the parent plant, or can set up an affiliate (through Foreign Direct Investment (FDI)) in the overseas country, thus jumping the costs of trade and selling locally. There are fixed costs to be incurred if

[2] This excludes FDI to tax havens such as Bermuda and other Caribbean states.
[3] Gammeltoft (2007), calculates using World Bank data, that outflows from the South account for 4.75% of global FDI for 2004.

the latter option is taken, in that a branch plant has to be set up. This idea is seen in Markusen and Venables (1998):

The decision to engage in multinational (multi-plant) production is a tension between the added fixed costs of a second plant versus the trade costs of serving the foreign market by exporting.

It is certainly the case, as proven in Baldwin and Ottaviano (2001), that trade and FDI are often complements. The literature finds instances both of complementarity and substitutability. Blonigen (2001), using product-level data for Japanese FDI in and exports to the US, finds that when FDI and exports are substitutes, (which is found to be the case for final automobile and consumer goods production at the product level) FDI replaces trade in a large one-time shift, rather than in a gradual fashion. This adds legitimacy to the modelling structure adopted here.

In the model, the determination of equilibrium depends on a combination of firm outputs and Fixed Costs of FDI. Greaney models firms that produce multiple differentiated goods, which gives her reverse imports to the country with network effects as a result, along with asymmetric "standard" exports and FDI. With the homogenous good structure adopted here asymmetric trade and FDI outcomes are arrived at, as in Greaney. Reverse imports, however are not possible in this setting, as firms will never serve their domestic market from abroad in a world of homogenous goods and Fixed Costs of FDI.

The advantage of adopting the homogenous good approach is that tractability is maintained when adding a new dimension to the model in the form of government policy. The policy treated here is a subsidy to the Fixed Costs of FDI. These policies have the power to shift firms between different regimes by altering their Fixed Costs. Optimal subsidy levels for both governments are arrived at, and welfare levels are calculated as governments engage in Nash behaviour.

In Section 2, the characteristics and assumptions of the model are outlined. In Section 3, the Nash Equilibrium outputs are specified for the four equilibria, for both the case including and excluding network effects. In Section 4, the location decisions of the firms are outlined. In Section 5, the effect of policy on the equilibrium outcome and subsequent national welfare is examined. Section 6 concludes.

2. The Model

In this model there are two countries, Home (H) and Foreign (F). There are two firms, 1 and 2. Firm 1 is based in H and Firm 2 is based in F. They produce a homogenous good in industry X . Firm 1's quantities of the good will be given the subscript 1, e.g. X_1, etc. The case for firm 2 is analogous.

The employment structure, wage levels, costs etc are considered identical in the two countries. They are also assumed similarly endowed in terms of labour, capital, human capital, technology etc. Production is of the nature that one unit of labour leads to one unit of output. The wage costs, w, are identical across countries. As mentioned before, the FDI in this model is of the "North-North" nature.

It is assumed that a domestic parent plant already exists in each country. The fixed costs of this plant are already incurred and it is for this reason that a firm never moves all its production to another similarly endowed country. Given the existence of a parent plant, with a homogenous good and in a North-North setting, a firm will never serve its own market by investing abroad, incurring both setup and export costs, and "reverse importing".

There are network costs, n, which are modelled as an additional cost for Firm 2 in selling to the Home market. This advantage for Firm 1 can be considered to exist due to exogenous cultural, historical, institutional or language reasons, as well as relationship-specific investments by intermediate and final good producers[4]. It is also possible that this could be endogenised, and be the subject of policy targets.[5]

It is possible and almost certainly the case that there will be a "network effect" in both countries, but for tractability the network effect in Foreign is normalised to zero, and the difference in strength between Home and Foreign network effects given by n.

Markets are segmented. This gives rise to two demand functions:

$$P_H = a - X_{1H} - X_{2H}$$

$$P_F = a - X_{1F} - X_{2F}$$

Where,

[4] This is the nature of the *keiretsu* network analysed in Spencer and Qiu (2001)

[5] This possible endogeneity raises the interesting question of the welfare effects of networks: while undeniably good for firms in the native country, are these network effects beneficial to overall welfare in the country? This question is addressed in Section 5.

X_{1H} is Firm 1 domestic sales in the Home market.

X_{2H} is Firm 2 sales in the Home market, which can be either through export or through a Firm 2 affiliate in Home.

X_{1F} is Firm 1 sales in the Foreign market, which can be either through export or a Firm 1 affiliate in Foreign

X_{2F} is Firm 2 domestic sales in the Foreign market.

There are three stages in this two-firm, two-country duopoly. The game is solved by backward induction.

In stage one, government sets a subsidy to the Fixed Cost of FDI to maximize national welfare. It is assumed that the government has perfect information about the firms' options.

In stage two, firms choose their location. The Fixed Costs of FDI are the defining factor in this decision.

In stage three, firms choose their outputs. In this model firms will never decide not to serve the overseas market. This means an assumption is being made regarding the quality of firm we are analysing. This is evidenced in empirical and theoretical work by Bernard and Jensen (1999) Melitz (2003), Helpman, Melitz and Yeaple (2004) Melitz and Ottaviano (2005) and many others regarding the characteristics of firms that engage in international trade and investment.

If the firm decides to set up an affiliate it will have to undergo a fixed cost of FDI, V.

In stage two, there are four possible equilibria. The titles given to these equilibria are borrowed from Greaney (2002). The first equilibrium is an N-type equilibrium, in which neither firm becomes a multinational. The second is an M-type equilibrium, in which both become multinational, i.e. both set up affiliates in the other country. The remaining two types are asymmetric equilibria, referred to as A-type equilibria, where one of the firms becomes multinational and the other remains domestic.

With homogenous products, products are strategic substitutes. This means that the reaction functions which lead to the equilibrium output levels are downward sloping.

Given that the game is solved by backward induction, I start with Section 3, which gives firm profit functions and equilibrium outputs in the presence of network effects. The special case where n=0 is outlined in brief at the end of the section.

3. Stage 3: Equilibrium outputs

Equilibrium outputs for each firm are calculated in the case of each of the four specified possible equilibria. They are calculated via the maximisation of a profit function which will depend on the equilibrium in question. The focus is on the case with network effects, followed by a brief description of the case where $n = 0$.

3.1 Equilibrium outputs and profits in the presence of network effects

N-type equilibrium with network effects

For the equilibrium in which both firms remain national, the profit functions are given as follows:

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$$\pi_1^N = (P_H - w - c)X_{1H} + (P_F - w - c - g)X_{1F}$$

$$\pi_2^N = (P_H - w - c - g - n)X_{1H} + (P_F - w - c)X_{2F}$$

At this point it is useful to define $\alpha = a - w - c$.

Here w is thought of as the "rent" extracted by labour in industry X, given by $w = w_X - \overline{w}$, where w_X is the wage paid by firms in industry X and $\overline{w}$ is the reservation wage that could be earned elsewhere in the economy. For tractability I assume that $\overline{w} = 0$.

The maximisation of the above functions leads to reaction functions, which are solved to give the following Nash Equilibrium outputs:

$$X_{1H} = \frac{\alpha + g + n}{3}$$

$$X_{2F} = \frac{\alpha + g}{3}$$

$$X_{1F} = \frac{\alpha - 2g}{3}$$

$$X_{2H} = \frac{\alpha - 2g - 2n}{3}$$

With network effects Firm 1 clearly has the highest output with its domestic sales, followed by Firm 2 domestic sales and Firm 1 exports. Firm 2 exports are of the lowest quantity, as in this instance Firm 2 faces both export and network costs.

M-type equilibrium with network effects

In the equilibrium in which both firms invest abroad, neither faces export costs. Firm 2 however still faces network costs and will thus be at a disadvantage. The possibility of government altering firm behaviour in earlier stages is accounted for by the inclusion of the s_i terms.

$$\pi_1^M = (P_H - w - c)X_{1H} + (P_F - w - c)X_{1F} - (V - s_F)$$

$$\pi_2^M = (P_H - w - c - n)X_{1H} + (P_F - w - c)X_{2F} - (V - s_H)$$

The maximisation of these profit functions leads to the following Cournot Nash Equilibrium outputs:

$$X_{1H} = \frac{\alpha + n}{3}$$

$$X_{1F} = X_{2F} = \frac{\alpha}{3}$$

$$X_{2H} = \frac{\alpha - 2n}{3}$$

Firm 1 domestic sales are the highest-selling variety here. Firm 1 affiliate and Firm 2 domestic sales are lower and equal due to there being no export or network costs associated with selling to the Foreign market. Firm 2 affiliate sales the lowest-selling variety due to the impossibility of avoiding network costs for Firm 2.

A_1-type equilibrium with network effects

In the asymmetric equilibrium in which only Firm 1 engages in FDI, the profit functions look at follows:

$$\pi_1^{AM} = (P_H - w - c)X_{1H} + (P_F - w - c)X_{1F} - (V - s_F)$$

$$\pi_2^{AN} = (P_H - w - c - g - n)X_{1H} + (P_F - w - c)X_{2F}$$

Where π_i^{AM} means firm i profit in the asymmetric equilibrium in which it is a multinational and π_i^{AN} denotes firm i profit in the asymmetric equilibrium in which it remains a national firm.

The maximisation of the above profit functions leads to the following Cournot Nash Equilibrium outputs.

$$X_{1H} = \frac{\alpha + g + n}{3}$$

$$X_{1F} = X_{2F} = \frac{\alpha}{3}$$

$$X_{2H} = \frac{\alpha - 2g - 2n}{3}$$

Here the ranking is the same as in the M-type equilibrium, with the difference between the top and bottom-selling varieties increasing in Firm 1's favour.

A_2-type equilibrium with network effects

In the equilibrium in which only Firm 2 invests abroad, the profit functions are as follows:

$$\pi_1^{AN} = (P_H - w - c)X_{1H} + (P_F - w - c - g)X_{1F}$$

$$\pi_2^{AM} = (P_H - w - c - n)X_{1H} + (P_F - w - c)X_{2F} - (V - s_F)$$

$$X_{2F} = \frac{\alpha + g}{3}$$

$$X_{1H} = \frac{\alpha + n}{3}$$

$$X_{2H} = \frac{\alpha - 2n}{3}$$

$$X_{1F} = \frac{\alpha - 2g}{3}$$

In this case engaging in multinational activity does not guarantee Firm 2 a sales advantage. The order of the top two and bottom two outputs depends on the relative strength of the network and export costs.

Condition 1: Given all the above outputs, the condition for an interior solution to exist can be given by $\alpha > 2(g + n)$

3.2 Equilibrium outputs and profits in the absence of network effects

This is simply a special case of the above Section 3.1 with $n = 0$.

This special case gives the following outputs:

N:

$$X_{1H} = X_{2F} = \frac{\alpha + g}{3}$$

$$X_{1F} = X_{2H} = \frac{\alpha - 2g}{3}$$

M:

$$X_{1H} = X_{1F} = X_{2F} = X_{2H} = \frac{\alpha}{3}$$

A_1:

$$X_{1H} = \frac{\alpha + g}{3}$$

$$X_{2F} = X_{1F} = \frac{\alpha}{3}$$

$$X_{2H} = \frac{\alpha - 2g}{3}$$

A_2:

$$X_{2F} = \frac{\alpha + g}{3}$$

$$X_{1H} = X_{2H} = \frac{\alpha}{3}$$

$$X_{1F} = \frac{\alpha - 2g}{3}$$

As can be seen, when $n = 0$ there is no advantage for Firm 1 and all equilibrium outcomes are perfectly symmetric. The outputs for Firm 1 in the A_1 Equilibrium are identical to those for Firm 2 in the A_2 Equilibrium. The following condition is also arrived at:

Condition 2: Given all the above outputs, the condition for an interior solution to exist in the case of $n = 0$ can be given by $\alpha > 2g$

4 Stage 2: Location Decision

4.1

Firms decide their location contingent on the Fixed Costs of FDI and output for both themselves and their rival.

The locational choices of the firms are inextricably linked to the notion of the subgame perfection of a given equilibrium.

For an equilibrium to be subgame perfect, the profit for each firm must be simultaneously greater than the profit to each firm from deviating. The conditions for each of the four equilibria to be subgame prefect are outlined in turn.

Profits in a given form are of the form $\pi = X^2$. See Appendix 1 for a derivation.

N subgame perfect

For the equilibrium in which both firms remain National to be subgame perfect (SGP), the following two conditions must simultaneously be met:

$\pi_1^N > \pi_1^{AM}$ and $\pi_2^N > \pi_2^{AM}$

$\pi_1^N > \pi_1^{AM}$

$$\left(\frac{\alpha+g+n}{3}\right)^2 + \left(\frac{\alpha-2g}{3}\right)^2 > \left(\frac{\alpha+g+n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V-s_F)$$

This leads to $(V-s_F) > \dfrac{4g(\alpha-g)}{9}$

$\pi_2^N > \pi_2^{AM}$

$$\left(\frac{\alpha-2g-2n}{3}\right)^2 + \left(\frac{\alpha+g}{3}\right)^2 > \left(\frac{\alpha+g}{3}\right)^2 + \left(\frac{\alpha-2n}{3}\right)^2 - (V-s_H)$$

This leads to $(V-s_H) > \dfrac{4g(\alpha-g-2n)}{9}$

Once the Fixed Cost of FDI is above the larger of these thresholds, N is the subgame perfect equilibrium.

For the propositions put forward in this section I focus for now on the "laissez-faire" case, where $s_H = s_F = 0$. Note that in Section 5 below this will not be the case as government intervention is considered.

In the absence of government action, N is subgame perfect if $V > \frac{4g(\alpha - g)}{9}$

M subgame perfect

$\pi_1^{M} > \pi_1^{AN}$ and $\pi_2^{M} > \pi_2^{AN}$

$\pi_1^{M} > \pi_1^{AN}$

$$\left(\frac{\alpha + n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_F) > \left(\frac{\alpha - 2g}{3}\right)^2 + \left(\frac{\alpha + n}{3}\right)^2$$

This leads to $(V - s_F) < \frac{4g(\alpha - g)}{9}$

$\pi_2^{M} > \pi_2^{AN}$

$$\left(\frac{\alpha - 2n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_F) > \left(\frac{\alpha - 2g - 2n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2$$

This leads to $(V - s_H) < \frac{4g(\alpha - g - 2n)}{9}$

M will be SGP if the Fixed Costs of FDI are less than the smaller of these two thresholds. Thus in the absence of government policy, M is subgame perfect if $V < \frac{4g(\alpha - g - 2n)}{9}$

A_1 subgame perfect

The asymmetric equilibrium in which Firm 1 invests in Foreign while Firm 2 remains a National firm is SGP if the following hold:

$\pi_1^{AM} > \pi_1^{N}$ and $\pi_2^{AN} > \pi_2^{M}$

$\pi_1^{AM} > \pi_1^{N}$

$$\left(\frac{\alpha + g + n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_F) > \left(\frac{\alpha - 2g}{3}\right)^2 + \left(\frac{\alpha + g + n}{3}\right)^2$$

This leads to $(V - s_F) < \frac{4g(\alpha - g)}{9}$

$\pi_2^{AN} > \pi_2^{M}$

$$\left(\frac{\alpha-2g-2n}{3}\right)^2+\left(\frac{\alpha}{3}\right)^2>\left(\frac{\alpha-2n}{3}\right)^2+\left(\frac{\alpha}{3}\right)^2-(V-s_H)$$

This leads to $(V-s_H)>\frac{4g(\alpha-g-2n)}{9}$

In the absence of any policy, this asymmetric equilibrium is SGP if

$$\frac{4g(\alpha-g-2n)}{9}<V<\frac{4g(\alpha-g)}{9}$$

<u>A_2 subgame perfect</u>

For the asymmetric equilibrium in which Firm 2 invests in Home while Firm 1 remains a National firm to be SGP, the following must hold:

$\pi_1^{AN}>\pi_1^{M}$ and $\pi_2^{AM}>\pi_2^{N}$

$\pi_1^{AN}>\pi_1^{M}$

$$\left(\frac{\alpha-2g}{3}\right)^2+\left(\frac{\alpha+n}{3}\right)^2>\left(\frac{\alpha+n}{3}\right)^2+\left(\frac{\alpha}{3}\right)^2-(V-s_F)$$

This leads to $(V-s_F)>\frac{4g(\alpha-g)}{9}$

$\pi_2^{AM}>\pi_2^{N}$

$$\left(\frac{\alpha+g}{3}\right)^2+\left(\frac{\alpha-2n}{3}\right)^2-(V-s_H)>\left(\frac{\alpha-2g-2n}{3}\right)^2+\left(\frac{\alpha+g}{3}\right)^2$$

This leads to $(V-s_H)<\frac{4g(\alpha-g-2n)}{9}$

These two conditions lead to the following range for A_2 to be SGP:

$$\frac{4g(\alpha-g)}{9}<V<\frac{4g(\alpha-g-2n)}{9}$$

For a positive n, this can never be subgame perfect, in the absence of government intervention.

The "laissez-faire" Stage 2 in the presence of network effects can be summarized as follows, and below in Proposition 1:

$$0<V<\frac{4g(\alpha-g-2n)}{9}<V<\frac{4g(\alpha-g)}{9}<V\to\infty$$

$$\cdots M\cdots\cdots\cdots\cdots\cdots\cdots A_1\cdots\cdots\cdots\cdots\cdots\cdots N\cdots\cdots$$

Proposition 1

With the existence of network effects, in the "laissez-faire" case, for a range of high V, the N-type equilibrium is SGP. In an intermediate range, the A_1 equilibrium is SGP, while for low V, M is SGP. A_2 can never be SGP in the absence of government intervention.

4.2 Stage 2 in the absence of network effects

In the special case of $n = 0$, there are only two equilibria which can be SGP in the absence of government action. The conditions for an SGP equilibrium are laid out exactly as in Section 4.1, leading to the following propositions:

Proposition 2a

In the "laissez-faire" case, in the absence of network effects, there is a clear threshold level of Fixed Costs of FDI, below which we have an M-type equilibrium and above which we have a N-type equilibrium. This can be summarized as follows:

$$0 < V < \frac{4g(\alpha - g)}{9} < V \to \infty$$

$$\cdots M \cdots\cdots\cdots\cdots\cdots\cdots N \cdots\cdots$$

Proposition 2b

Neither asymmetric equilibrium can be subgame perfect in the absence of network effects, except if a government offers a subsidy to the Fixed Costs of FDI to one firm alone.

5. Stage 1: Introducing government policy

In this section the effect that government policy can have on firm behaviour and welfare is examined. The policy in question is a subsidy to the Fixed Cost of FDI. Examples of these may include the provision of infrastructure, the cost of which would otherwise have been borne by the MNC; direct subsidies to the plant setup costs of MNCs; removal of lump-sum regulatory fees. Chor (2007) states that subsidies to Variable Costs can induce larger welfare gains than those to Fixed Costs, for the same total subsidy bill. This is so because a Variable Cost subsidy alters both entry and production decisions of firms whereas Fixed Cost subsidies only affect the former. He uses a similar modelling structure to Helpman, Melitz and Yeaple (2004) and shows that a subsidy induces only the most productive exporters to switch to FDI. Given that the welfare analysed in Chor's paper consists solely of a consumption measure, the welfare effects of subsidising inward FDI may not be explored to a large enough extent. He claims "the consumption gains are perhaps the most direct benefit: The relocation of production lowers the prices that MNCs charge in their host country's market, due to the savings on cross-border transport costs and also possibly labour costs". I argue here that perhaps a fuller definition of national welfare is required to analyse the conditions under which inward FDI is beneficial to the host country. Chor does go on to acknowledge that (his approach) "puts aside other potential benefits such as technological spillovers, agglomeration effects, or an increased demand for local labour". While the two former effects cannot be modelled in this oligopoly setting, the latter is accounted for here, along with another arguably important effect of inward FDI, that on native host-country firms, as well as a measure of Consumer Surplus[6]. The Welfare Function specified below is similar to that in Collie and Vandenbussche (2001). One major difference is that labour compensation, referred to as "union rents" in their paper, can be zero in a given country under certain regimes, due to the fact that they assume that a firm can shift all production abroad and serve its own market through "reverse imports", even under the assumption of homogenous goods. As mentioned already, with a domestic parent plant already in place and homogenous goods, a firm will never fully leave its

[6] The importance of the "market-seeking FDI" assumption is emphasised here again. If reverse imports or export-platform FDI were at play here, a portion of Consumer Surplus resulting from inward FDI would accrue to third-party consumers rather than those in the host country. This issue is raised in Chor (2007)

domestic country in my model. The “lump-sum” nature of Fixed Cost subsidies means that they can only initiate once-off discontinuities in the Welfare function, also referred to as a regime shift.

5.1 Government policy in the absence of network effects

Unlike previous sections, I will begin with the analysis of the special case of $n = 0$ and build up the case including network effects. This will make it easier to indicate the effects of the business and social network on both countries. For the case with $n = 0$ the results will be symmetric, so only one country needs to be examined in any detail. I arbitrarily select Home fro the analysis below. It should be noted that in this section it is assumed that we begin in an N equilibrium, where the Fixed Costs of FDI are prohibitively high and both firms are National firms. This assumption means there are more shifts in equilibrium that each government can initiate with a subsidy to the Fixed Costs of FDI.

5.1.1 Welfare Functions

A Home Welfare Function must first be specified. It is given by:

$$W_H = CS_H + \pi_1 + w\mathrm{Z}_\mathrm{H} - s_H$$

Where

W is national welfare

CS_H is Home Consumer Surplus

This is given by

$$\frac{\left(X_H^2\right)}{2}$$

Where $X_H = X_{1H} + X_{2H}$, where X_{ij} implies sales of Firm i in country j, the form of which can change depending on the equilibrium in question.

w is the wage level. It is assumed that the rent workers extract is the same as the wage the firm pays, due to the assumption that $\overline{w} = 0$ from earlier.

Z_H is production on Home soil. This can differ from sales, depending on the equilibrium in question.

wZ_H is referred to as Labour Compensation.

s_i is the subsidy level which will be given to the Fixed Costs of inward FDI by the government of country i.

It will now be useful to detail in full the Home Welfare Function for each equilibrium, given the outputs calculated in the previous section.

It is useful to remark at this stage that I assume, due to the partial equilibrium nature of the analysis, that the wage level will be constant in each country for each of the four possible equilibria, regardless of the number of products being produced.

<u>N-type equilibrium.</u>

In the N-type equilibrium, Home Consumer Surplus is calculated using the sum of Firm 1 domestic sales, and Firm 2 exports. The labour compensation element is given by the wage multiplied by the sum of Firm 1 domestic sales and exports. In the N-type equilibrium there is no multinational activity and hence no subsidy.

The Welfare Function looks as follows:

$$W_H^N = \frac{\left(\frac{2\alpha - g}{3}\right)^2}{2} + \left(\frac{\alpha + g}{3}\right)^2 + \left(\frac{\alpha - 2g}{3}\right)^2 + w\left(\frac{2\alpha - g}{3}\right)$$

CS *Firm 1 Profits* *Labour Compensation*

<u>M-type equilibrium</u>

In the M-type equilibrium, Home Consumer Surplus is calculated using the sum of Firm 1 domestic sales and Firm 2 affiliate sales. Labour Compensation is given by the wage multiplied by the sum of Firm 1 domestic output and Firm 2 affiliate output.

$$W_H^M = \frac{\left(\frac{2\alpha}{3}\right)^2}{2} + \left(\frac{\alpha}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_F) + w\left(\frac{2\alpha}{3}\right) - s_H$$

CS *Firm 1 Profits* ↑ *Subsidy*

Labour Compensation

A$_1$-type equilibrium

In the asymmetric equilibrium with only Firm 1 as a multinational, Home Consumer Surplus is calculated in the same way as in the N-type equilibrium. Labour Compensation is calculated by multiplying wages by Firm 1 domestic production only. All other production takes place in Foreign in this equilibrium. There is no investment by Firm 2 in this equilibrium, so $s_H = 0$

$$W_H^{A1} = \frac{\left(\frac{2\alpha - g}{3}\right)^2}{2} + \left(\frac{\alpha}{3}\right)^2 + \left(\frac{\alpha + g}{3}\right)^2 - (V - s_F) + w\left(\frac{\alpha + g}{3}\right) - s_H$$

CS *Firm 1 Profits* ↑ *Subsidy*

Labour Compensation

A$_2$-type equilibrium

In the asymmetric equilibrium with only Firm 2 as a multinational, Home Consumer Surplus is calculated in the same way as in the M-type equilibrium. Labour Compensation is calculated as wages multiplied by the sum of Firm 2 affiliate output, Firm 1 domestic sales, and Firm 1 exports.

$$W_H^{A2} = \frac{\left(\frac{2\alpha}{3}\right)^2}{2} + \left(\frac{\alpha - 2g}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 + w\left(\frac{3\alpha - 2g}{3}\right) - s_H$$

CS *Firm 2 Profits* ↑ *Subsidy*

Labour Compensation

5.1.2 Unilateral subsidy

To begin, the arrival at the optimal unilateral Home government subsidy level will be outlined. Home government inward Fixed Costs subsidies can initiate two regime shifts: that from N to A$_2$ and from A$_1$ to M. In the case with no network effects, the A$_1$ equilibrium is not possible to begin with without asymmetric Fixed Costs, so is not examinable.

The welfare change under the shift from N to A_2 is outlined. Due to symmetry between all outputs in the absence of network effects, this welfare change is the same as that under the shift from N to A_1 in the case of Foreign government policy.
The change in the return to each "partner" in the Welfare Function is given:

$$CS_H \uparrow \frac{1}{2}\left(\frac{4\alpha g - g^2}{9}\right)$$

$$\pi_1 \downarrow \frac{2\alpha g + g^2}{9}$$

$$L.C. \uparrow \frac{w(\alpha - g)}{3}$$

Government finances $\downarrow s_H$

For the move from N to A_2 to be welfare-improving, the sum of the terms must be greater than zero. $\hat{s}_i$ is the subsidy level below which Welfare will improve for the shift from N to A_2 or N to A_1. It is the same for both countries due to symmetry:

$$\hat{s}_H = \hat{s}_F < \frac{w(\alpha - g)}{3} - \frac{3}{2}\left(\frac{g^2}{9}\right).$$

It is shown earlier that $(\alpha - g) > 0$. What can be seen here is that if $w = 0$ (which would be the case if $w_X = \bar{w}$, i.e. there were no "labour rents" in the sector), the only welfare-improving subsidy level is a negative one. In practice this instance will never arise as an FDI tax will not attract FDI, thus making the move from N to A_2 impossible. Thus there must exist "labour rents" (i.e. a positive w, and consequently a positive $w\frac{(\alpha - g)}{3}$) for the subsidy to be justifiable. This is clear if one thinks of the first term as being the benefit to local labour of FDI, and the second term as being the (in this case negative) balance of the gains to consumers and the loss to the local firm. Even when the term $w\frac{(\alpha - g)}{3}$ is greater than zero, it is still possible that there will be a negative optimal subsidy level[7]. It would happen at high levels of export costs, $g^2 > 2w(\alpha - g)$. This is intuitive, as when export costs are particularly high, the

[7] Which effectively means a zero optimal subsidy as negative subsidies are not possible when documenting the shift from N to A_2.

losses incurred by Firm 1 would offset the gains to both local consumers and local labour, meaning there would be no positive subsidy level which could lead to an overall welfare gain.

5.1.3 Optimal Unilateral Subsidy

In calculating the optimal subsidy level, it must be taken into account that there is no guarantee that the welfare-improving level should coincide with a level that will entice the overseas firm to invest. For this I calculate $\bar{s}$, the subsidy level above which the regime shift is profitable for the overseas firm. Due to symmetry, results for Firm 2 investing in Home are identical to those for Firm 1 investing in Foreign. As in the welfare case, the threshold for the $N \rightarrow A_2$ shift is identical to that for the $A_1 \rightarrow M$ shift.

The subsidy from the Home government that will induce Firm 2 to invest is arrived at by simultaneously solving the following:

$V > \frac{4g(\alpha - g)}{9}$. Condition for Firm 1 to remain national in N or A_2 and Firm 2 to remain national in N.

$(V - \bar{s}_H) < \frac{4g(\alpha - g)}{9}$. Condition for Firm 2 to become multinational in an A_2 type equilibrium.

For these to simultaneously be true, the condition must be that the subsidy at least covers the difference between the current Fixed Cost level and the prohibitive Fixed Cost level. This is given by $\bar{s}_H > V - \frac{4g(\alpha - g)}{9}$.

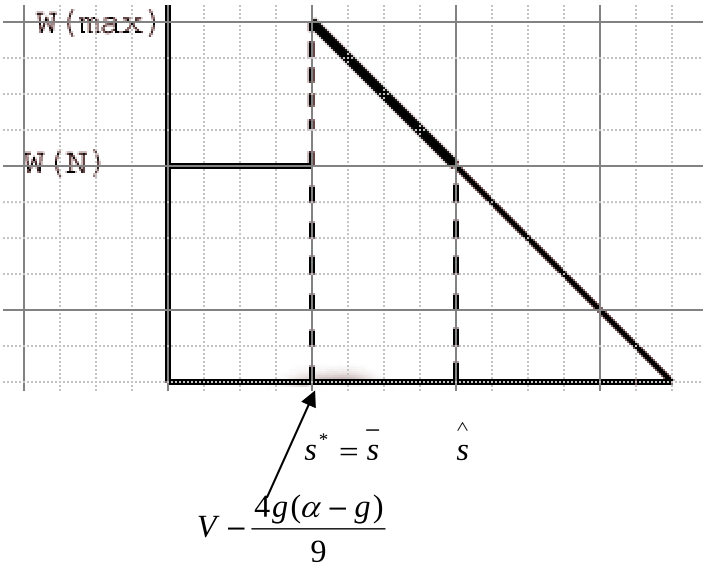
For there to be an optimal subsidy level, the subsidy which entices Firm 2 to invest in Home must be less than that below which there are welfare improvements. Denote the optimal subsidy level s^*. The condition for there to be welfare improvements, i.e. $\bar{s} < s^* < \hat{s}$, is subject to the following parameter restriction:

$\bar{s} < \hat{s}$

Which is given here by

$V < \frac{3w(\alpha - g) + 4\alpha g - 11/2(g^2)}{9}$. Outside of this range, i.e. $\bar{s} > \hat{s}$, the government will not offer the subsidy, as the subsidy level required to induce Firm 2 to invest in Home would lead to a welfare loss. Thus outside this range, considering the assumed prohibitive Fixed Cost levels, N is the only possible equilibrium.

The relationship between subsidies and Welfare can be graphed. It is assumed in this analysis that the starting point is in the N-type equilibrium, with prohibitively high Fixed Costs and no multinational activity. This picture is the same for both governments in the special case of $n = 0$.



It is assumed that the starting point is in the N equilibrium where $V > \frac{4g(\alpha - g)}{9}$. In the graph we see that until $\bar{s}$ the welfare curve is flat. This is so due to there being no effect on equilibrium of any subsidy below that level. Once $\bar{s}$ is reached, there is a once-off jump in welfare (provided the parameters satisfy $\bar{s} < \hat{s}$), to the Welfare level associated with the A_2 equilibrium. Welfare then drops one for one with the subsidy level, as any subsidy payment beyond the level that just attracts Firm 2 is a deadweight contribution to Firm 2 profits. $\hat{s}$ is as before the subsidy level at which welfare is the same in the N and A_2 equilibria.

The optimal subsidy level, s^* is given by the level which maximises welfare. In this case $s^* = \bar{s}$.

Proposition 3

The optimal Home (Foreign) Government Fixed Cost subsidy level is that which just entices Firm 2(1) to invest in Home (Foreign). For the case of $n = 0$ this is given by $V - \frac{4g(\alpha - g)}{9}$

Proposition 4

The $A_{2(1)}$ equilibrium arrived after the offering of the optimal unilateral Home (Foreign) subsidy is a Nash Equilibrium in the parameter space $\bar{s} < \hat{s}$. For the given Fixed Cost level, $V > \frac{4g(\alpha - g)}{9}$ and subsidy level $s^* = V - \frac{4g(\alpha - g)}{9}$, neither firm has an incentive to deviate from the asymmetric equilibrium in question.

The results for the shift from A_1 to M are the exact same as those for N to A_2.

Due to symmetry in the absence of network effects, the above results all apply to the case for the Foreign government in initiating both the N to A_1 and A_2 to M regime shifts.

5.1.4 Retaliatory Subsidies

So far it is shown that there is an optimal subsidy level for both regime shifts that are possible for each government. Governments have thus far been looked at as acting in somewhat of a "vacuum", in which the subsidy choice of one does not affect that of the other. To enrich the analysis, the case of retaliatory subsidies is now covered.

If we assume that the game starts in the N equilibrium (i.e. where $V > \frac{4g(\alpha - g)}{9}$),

then in the range $\bar{s} < \hat{s}$ [8], the dominant strategy for both governments is to offer $s^* = \bar{s}$. In the symmetric case without network effects, this leads to a Nash equilibrium subsidy pair of $(s_H, s_F) = \left(V - \frac{4g(\alpha - g)}{9}, V - \frac{4g(\alpha - g)}{9}\right)$.

[8] In this case, $\bar{s} < \hat{s}$ holds when $V^{NASH} < \frac{3w(\alpha - g) + 4g(\alpha - g) - \frac{3}{2}(g^2)}{9}$.

This subsidy pair leaves the game in an M-type equilibrium, with both Firms investing abroad. Outside the parameter space $\bar{s} < \hat{s}$ the Nash equilibrium is always of the N-type.

The question of whether or not this Nash Equilibrium is welfare-improving must now be asked. To answer this question welfare under the M and N equilibria must be compared.

In order for the M-type Nash Equilibrium to be welfare-improving the condition $W_H^M - W_H^N > 0$ must be satisfied. This simplifies down to

$V^{M \succ N} < \dfrac{3wg + 4\alpha g - {}^{11}\!/_{2}(g^2)}{9}$. To complete this analysis it must be recalled that for the strategic behaviour resulting in the M-type Nash Equilibrium to occur, the following parameter range must be satisfied:

$V^{NASH} < \dfrac{3w(\alpha - g) + 4g(\alpha - g) - {}^{3}\!/_{2}(g^2)}{9}$.

If checking if $V^{M \succ N} - V^{NASH} > 0$.

This subtraction simplifies to $3w(2g - \alpha) > 0$.

If this term is positive then it can be said that the M-type Nash equilibrium is always welfare-improving. However, as detailed below, it is always the case that $V^{M \succ N} - V^{NASH} < 0$.

If we recall Condition 2, which was an interior solution condition in Section 3.1.1: $\alpha - 2g > 0$, and the fact that labour rents are always greater than or equal to zero, then $2w(2g - \alpha)$ is unambiguously negative. Therefore $V^{M \succ N} - V^{NASH} < 0$ is always the case. This implies that, in the M-type Nash Equilibrium resulting from unilateral government behaviour, there are two distinct parameter ranges: that in which the shift to M improves welfare, and that in which the shift reduces welfare.

This can be put as follows

Proposition 5

In the parameter range which will induce the M-type equilibrium to be a Nash Equilibrium with governments behaving strategically ($V < V^{NASH}$), the move from N to M results in a welfare reduction in the range $V^{M \succ N} < V < V^{NASH}$, and results in a welfare improvement in the range $0 < V < V^{M \succ N}$

Proposition 6

The move to M which is a Nash Equilibrium in the appropriate parameter space, results in a lowering of profits for both firms. See Appendix 2 for derivation of this result.

5.2 Government policy with the inclusion of network effects

Optimal government policy with network effects included is now examined. All the methodology and terminology are identical to Section 5.1.

5.2.1 Home Government Policy in the presence of network effects

The inclusion of network effects in the model leads to an asymmetry in the countries' welfare functions. The Home Welfare Function and optimal subsidy level is first detailed. As in previous sections, the Welfare Function under the four equilibria is outlined first.

<u>N-type equilibrium.</u>

$$W_H^N = \frac{\left(\frac{2\alpha - g - n}{3}\right)^2}{2} + \left(\frac{\alpha + g + n}{3}\right)^2 + \left(\frac{\alpha - 2g}{3}\right)^2 + w\left(\frac{2\alpha - g + n}{3}\right)$$

CS *Firm 1 Profits* *Labour Compensation*

We see consumers are worse off, Firm 1 better off, and workers better off in Home than in the case with $n = 0$. Consumers are worse off as Firm 1 always sells into the Home market, and faces a cost disadvantage from the network effects. Firm 1 is better off due to the network advantage. Workers are better off as only Firm 1, with its network advantage, produces on Home soil in this equilibrium.

<u>M-type equilibrium</u>

$$W_H^M = \frac{\left(\frac{2\alpha - n}{3}\right)^2}{2} + \left(\frac{\alpha + n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - V + w\left(\frac{2\alpha - n}{3}\right) - s$$

CS *Firm 1 Profits* *Subsidy*

Labour Compensation

Again consumers are worse off and Firm 1 better off. Workers however are now worse off. This is because Firm 2 is now producing on Home soil, and still faces the cost disadvantage associated with the network effect.

<u>A_1-type equilibrium</u>

$$W_H^{A1} = \frac{\left(\frac{2\alpha - g - n}{3}\right)^2}{2} + \left(\frac{\alpha}{3}\right)^2 + \left(\frac{\alpha + g + n}{3}\right)^2 - V + w\left(\frac{\alpha + g + n}{3}\right) - s$$

CS *Firm 1 Profits* *Subsidy*

Labour Compensation

The comparisons with the $n = 0$ case for each partner are the same as for the N-tye equilibrium: Consumers are worse off, while Firm 1 and workers are better off.

<u>A_2-type equilibrium</u>

$$W_H^{A2} = \frac{\left(\frac{2\alpha - n}{3}\right)^2}{2} + \left(\frac{\alpha - 2g}{3}\right)^2 + \left(\frac{\alpha + n}{3}\right)^2 + w\left(\frac{3\alpha - 2g - n}{3}\right) - s$$

CS *Firm 2 Profits* *Subsidy*

Labour Compensation

The comparisons with the $n = 0$ case are the same as those for the M-type equilibrium.

Inward Home government policy can initiate two regime shifts. The first to be detailed is that from the N-type to A_2-type equilibrium. The changes in Welfare resulting from this shift are as follows:

$$CS_H \uparrow \frac{1}{2}\left(\frac{4\alpha g - g^2 - ng}{9}\right)$$

$$\pi_1 \downarrow \frac{2\alpha g + g^2 + ng}{9}$$

$$L.C. \uparrow \frac{w(\alpha - g - 2n)}{3}$$

Government finances $\downarrow s_H$

The network effects impact negatively on each component of the Home Welfare function when compared to the case without network effects. The range of Welfare-improving s is given by:

$$\hat{s}_H < \frac{w(\alpha - g - 2n)}{3} - \left(\frac{\frac{3}{2}g^2 + 3ng}{9} \right)$$

The inclusion of network effects results in a smaller range of Welfare-improving subsidy levels for Home. The possible welfare improvements for the Home government from the attraction of inward foreign investment are lower when local business is benefiting from network effects. While Home consumers and workers still benefit from the arrival of Firm 2, this benefit is of a lower magnitude than in the case without network effects. This is due to Firm 2 having a cost disadvantage in selling to the Home market. As in the case without network effects, Firm 1 suffers a profit decrease from the arrival of Firm 2. The decrease is in fact larger in the presence of network effects than in the case without. In summary, for the N to A_2 shift, the range in which Home Welfare improves is unambiguously smaller.

The second shift that the Home government can initiate through policy is that from an A_1 to M-type equilibrium. As in the case without network effects, the encouragement of investment from the rival Firm into the domestic economy leads to the exact same Welfare shift, no matter which equilibrium switch is in question. The Welfare-improving subsidy threshold is the same as that for the N to A_2 shift, with the same disparities when compared to the analogous shift in the absence of network effects.

$$\hat{s}_H < \frac{w(\alpha - g - 2n)}{3} - \left(\frac{\frac{3}{2}g^2 + 3ng}{9} \right)$$

The method of arriving at the optimal subsidy is identical to Section 5.1.3.

The subsidy level that will induce Firm 2 to invest in Home, $\bar{s}$, is given by the difference between the Fixed Cost of Firm 2 and Firm 2's threshold Fixed Cost level.

For this to be the case $V > \frac{4g(\alpha - g - 2n)}{9}$ still holds, while

$V - \bar{s}_H < \frac{4g(\alpha - g - 2n)}{9}$ must hold for the subsidy to attract Firm 2.

This leaves $\bar{s}_H \geq V - \frac{4g(\alpha - g - 2n)}{9}$.

With the above information, and for the parameter range $\bar{s} < \hat{s}$ the optimal subsidy level is easily calculated, as in Section 5.1.3, as the subsidy which just attracts Firm 2 to invest in Home. Anything beyond this level is simply a deadweight contribution to Firm 2 profits.

This subsidy level can be combined with $\hat{s}$ to give the range in which the optimal subsidy must lie, $\bar{s} < s^* < \hat{s}$, which in this case gives the following range of Fixed Cost:

$V_H^{NASH} < \dfrac{3w(\alpha - g - 2n) - (\frac{11}{2} g^2 + 11gn - 4\alpha g)}{9}$ [9]. If V is above this level, the move from N to A_2 will not take place and N will be the Nash Equilibrium.

Proposition 7

In the appropriate parameter range, given by $V < V^{NASH}$ the optimal Home subsidy with the inclusion of network effects is $s^*_H = \overline{s_H} = V - \dfrac{4g(\alpha - g - 2n)}{9}$

Proposition 7a

The shift from N to A_2 initiated by the offering of $s^*_H = \bar{s}_H = V - \dfrac{4g(\alpha - g - 2n)}{9}$

results in a Nash Equilibrium in the parameter range $\bar{s} < s^* < \hat{s}$. This is the case as neither firm has an incentive to deviate given the Fixed Cost and subsidy levels in question.

5.2.2 Foreign Government Policy

Unlike Section 4.1, there is no symmetry in this case, due to the inclusion of network effects. The Welfare Function and subsequent subsidy levels will be different for the Home and Foreign governments. The layout of the Welfare Function will be identical to those calculated in previous sections. Welfare under the four regimes is given below

[9] This is denoted V^{NASH} as it is the same threshold that will be used to determine Nash Equilibrium in the next Section.

$$W_F^N = \frac{\left(\frac{2\alpha - g}{3}\right)^2}{2} + \left(\frac{\alpha - 2g - 2n}{3}\right)^2 + \left(\frac{\alpha + g}{3}\right)^2 + w\left(\frac{2\alpha - 2n - g}{3}\right)$$

CS *Firm 2 Profits* *Labour Compensation*

For the N equilibrium, Consumers are indifferent between this case and $n = 0$. Firm 2 prefers the $n = 0$ case, as do workers. Workers are better off without network effects as only Firm 2, which faces the network cost disadvantage, produces on Foreign soil in this equilibrium

$$W_F^M = \frac{\left(\frac{2\alpha}{3}\right)^2}{2} + \left(\frac{\alpha - 2n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_H) + w\left(\frac{2\alpha}{3}\right) - s_F$$

CS *Firm 2 Profits* *Subsidy*
Labour Compensation

Again Consumers are indifferent between this and the $n = 0$ case. Firm 2 is again worse off, while labour is also indifferent. This is because production on Foreign soil is solely for sale in the Foreign market, and thus not affected by the network effect in Home.

$$W_F^{A1} = \frac{\left(\frac{2\alpha}{3}\right)^2}{2} + \left(\frac{\alpha - 2g - 2n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 + w\left(\frac{3\alpha - 2g - 2n}{3}\right) - s$$

CS *Firm 2 Profits* *Subsidy*
Labour Compensation

Here consumers are indifferent, Firm 2 is worse off, and workers are worse off. This is because a portion of Firm 2 production on Foreign soil is for export to the Home market and suffers the network disadvantage.

$$W_F^{A2} = \frac{\left(\frac{2\alpha - g}{3}\right)^2}{2} + \left(\frac{\alpha - 2n}{3}\right)^2 + \left(\frac{\alpha + g}{3}\right)^2 - V + w\left(\frac{\alpha + g}{3}\right) - s$$

CS *Firm 2 Profits* *Subsidy*
Labour Compensation

Here consumers are indifferent, Firm 2 is worse off, and workers are also indifferent due to the only production on Foreign soil being Firm 2 domestic sales, which are not affected the Firm 1network advantage.

The regime shifts that can be initiated by the Foreign government are

$N \to A_1$ and $A_2 \to M$.

$\hat{s}_F$, the subsidy level below which Welfare will improve for a given regime shift, is calculated for the $N \rightarrow A_1$ shift is $\hat{s}_F < \frac{w(\alpha - g)}{3} - \frac{3}{2}\left(\frac{g^2}{9}\right)$, which is larger than that for the Home government and identical to the $n = 0$ case.

The subsidy level that will attract Firm 1 to invest in Foreign is given as follows:

$$\bar{s}_F \geq V - \frac{4g(\alpha - g)}{9}$$

These are combined to give the range in which the optimal subsidy will exist $\bar{s} < s^* < \hat{s}$. This is given in terms of the threshold Fixed Cost level below which the optimal subsidy can exist

$$V_F^{NASH} < \frac{3w(\alpha - g) + 4\alpha g - \frac{11}{2}g^2}{9}$$

This is also larger than that for Home, indicating that there is a larger parameter range in which the Foreign government can improve welfare.

Proposition 8

In the appropriate parameter range, given by $V < V^{NASH}$, the optimal Foreign government subsidy in the presence of network effects is $s_F^* = \bar{s}_F = V - \frac{4g(\alpha - g)}{9}$

Proposition 8a

The shift from N to A_1 initiated by the offering of $s_F^* = \bar{s}_F = V - \frac{4g(\alpha - g)}{9}$ is a Nash Equilibrium in the range $\bar{s} < s^* < \hat{s}$. For the given Fixed Cost and subsidy levels it is optimal for both firms not to deviate.

5.2.3 Retaliatory Case

Given that above the optimal unilateral subsidy levels for Home and Foreign are calculated, an analysis of the case in which subsidy levels affect each other is a logical advancement.

If we assume as in Section 4.1 that the game starts in the N equilibrium (i.e. where $V > \frac{4g(\alpha - g)}{9}$), then in the range $\bar{s} < \hat{s}$ [10], the dominant strategy for both governments is to offer $s^* = \bar{s}$. In this case with network effects, this leads to a Nash equilibrium subsidy pair of $(s_H, s_F) = \left(V - \frac{4g(\alpha - g - 2n)}{9}, V - \frac{4g(\alpha - g)}{9}\right)$.

This subsidy pair leaves the game in an M-type equilibrium, with both Firms investing abroad. Outside the parameter space $\bar{s} < \hat{s}$ the Nash equilibrium is always of the N-type.

The question of whether or not this Nash Equilibrium is welfare-improving must now be asked. To answer this question welfare under the M and N equilibria must be compared.

In order for the M-type Nash Equilibrium to be welfare-improving the condition $W_H^M - W_H^N > 0$ must be satisfied.

For Home, this condition simplifies to

$$V_H^{M \succ N} < \frac{3w(g - 2n) - (\frac{9}{2}g^2 + 3ng - 4\alpha g)}{9} + s_F - s_H .$$

In Section 5.1.4, the two subsidy levels cancelled out due to symmetry. This will not be the case this time. Substituting the two subsidy levels into the above gives

$$V_H^{M \succ N} < \frac{3w(g - 2n) - (\frac{11}{2}g^2 + 11ng - 4\alpha g)}{9}$$

As before, this must be compared with V^{NASH}

If $V^{M \succ N} > V^{NASH}$, the shift from N to M is always welfare-improving. This is tested by subtracting $V^{M \succ N} - V^{NASH} > 0$.

This subtraction simplifies to $3w(2g - \alpha) > 0$.

If this term is positive then it can be said that the M-type Nash equilibrium is always welfare-improving. However, it is always the case that $V^{M \succ N} - V^{NASH} < 0$, due to the interior solution condition in the case with network effects, $\alpha > 2g + 2n$

[10] In this case, $\bar{s} < \hat{s}$ holds when $V < V^{NASH}$ for both countries.

Therefore $V_H^{M \succ N} - V_H^{NASH} < 0$ is always the case. This implies that, in the M-type Nash Equilibrium resulting from unilateral government behaviour, there are two distinct parameter ranges: that in which the shift to M improves welfare, and that in which the shift reduces welfare.

Proposition 9

In the parameter range which will the Home government to attract investment from Firm 2 ($V < V^{NASH}$), the move from N to M results in a welfare reduction in the range $V^{M \succ N} < V < V^{NASH}$, and results in a welfare improvement in the range $0 < V < V^{M \succ N}$

For the Foreign case there will be different results

$$V_F^{M \succ N} < \frac{3w(2n+g) - (\frac{11}{2}g^2 + 8ng - 4\alpha g)}{9} + s_F - s_H .$$

Substituting the two subsidy levels into the above gives

$$V_F^{M \succ N} < \frac{3w(2n+g) - (\frac{11}{2}g^2 - 4\alpha g)}{9}$$

As above, this must be compared with V_F^{NASH}

If $V_F^{M \succ N} > V_F^{NASH}$, the shift from N to M is always welfare-improving for the Foreign government. This is tested by subtracting $V_F^{M \succ N} - V_F^{NASH} > 0$.

This subtraction simplifies to $3w(2g + 2n - \alpha) + 8gn > 0$.

If this term is positive then it can be said that the M-type Nash equilibrium is always welfare-improving for Foreign. Unlike the Home case, it is not always the case that $V^{M \succ N} - V^{NASH} < 0$. $V_F^{M \succ N} - V_F^{NASH} > 0$ holds if $n > \frac{3w(\alpha - 2g - 2n)}{8g}$. This implies that, for strong network effects, it is possible that there is no range of Fixed Costs in which Foreign Welfare decreases as a result of the jump to the M equilibrium.

This can be put as follows

Proposition 10a

In the parameter range with strong network effects, $V_F^{M \succ N} - V_F^{NASH} > 0$ holds, and every move from N to M is Welfare-improving for Foreign.

Proposition 10b

In the parameter range with weak network effects, once $V < V^{NASH}$, the move from N to M results in a welfare reduction in the range $V^{M \succ N} < V < V^{NASH}$, and results in a welfare improvement in the range $0 < V < V^{M \succ N}$

From propositions 10, 10a and 10b, it can be seen that in the retaliatory case with network effects, there is a stronger likelihood of the Foreign government improving welfare. This shows that the network effect, which in Section 3 was shown to benefit firms native to Home, is in fact not conducive to overall welfare improvements in the case where governments can only offer subsidies to the Fixed Costs of inward FDI. This finding can shed some light on the conundrum surrounding the business linkages in countries such as Japan. While they do lead to trade and FDI imbalances, the suggestion here is that in a wider context there business networks may not be beneficial for the country itself, when consumers and workers are taken into account.

Proposition 11

As in the $n = 0$ case, in the appropriate parameter space and with the subsidy levels that lead to M being a Nash Equilibrium, both firms would be better off in the N equilibrium than they are in the M equilibrium. This result is proven in Appendix 3.

This, along with Proposition 6, show that government rivalry does nothing to enhance the fortunes of native firms, when the government pursues a wider Welfare agenda.

6 Conclusions

In this paper I have modelled a homogenous-good version of Greaney's (2002) model, allowing for asymmetric trade and FDI outcomes in a two country, two firm duopoly. The factor driving the asymmetric outcome in this model is a "network effect". Greaney explains the network effect as follows: "the added cost may reflect search costs involved in locating buyers, distribution costs and/or information costs that are assumed to be higher for "outsiders" in some markets".

It is shown that the firm native to the country with the network effect fairs better under all equilibria than it did in the absence of network effects. The opposite is shown to be true for the firm in the country with weaker network effects.

The homogenous good modelling strategy employed here allows for the potential impact of government policy to be included in the network effect model. The policy analysed here is a subsidy to the Fixed Cost of FDI, applied only to inward FDI. National Welfare Functions are specified for both nations in the case both with and without network effects. An interesting aspect of this type of model is that as subsidy levels rise, the firms pass through different "regimes" or equilibria, based on which of them are engaged in multinational activity. Government chooses the optimal subsidy level which maximises welfare for the regime shift in question. In the case without network effects, in the appropriate parameter space, Nash behaviour drives both governments to offer their optimal subsidy, leaving the game in the M equilibrium with both firms engaging in foreign investment. It is shown that in this parameter space there is a range of Fixed Costs that leads to an overall welfare loss from this Nash behaviour.

An interesting finding of the paper is that with the inclusion of network effects, it is more likely that the Foreign government will realise a Welfare improvement from the strategic firm and government behaviour in this model. The conclusion drawn is thus that network effects, although good for the Home firm, may not be beneficial to Home as a whole. Furthermore, strategic interaction between governments pursuing a wide Welfare agenda is likely to lead to losses for firms in those countries.

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APPENDIX 1

Profits for each equilibrium are calculated as follows:

Operating profits in each market are equal to the square of output from the first order conditions for output.

The profit function is derived as follows:

$$\pi = (p - c)X$$

Where c here comprises wages, other marginal costs, and some combination of export costs and network costs, depending on the firm and equilibrium in question.

$$\delta\pi / \delta X = (p - c) + p' X$$

p' = -1 in this instance.

$$\delta\pi / \delta X = 0$$

The FOC are solved to give

$$\pi = X^2$$

APPENDIX 2

$$\pi_N = \left(\frac{\alpha + g}{3}\right)^2 + \left(\frac{\alpha - 2g}{3}\right)^2$$

$$\pi_M = \left(\frac{\alpha}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s)$$

$$N \succ M \text{ if } V - s > \frac{g(2\alpha - 5g)}{9}$$

$$s = V - \frac{4g(\alpha - g)}{9}$$

The statement above now reads

$$\frac{4g(\alpha - g)}{9} > \frac{g(2\alpha - 5g)}{9}$$

Which holds if

$$2\alpha + g > 0$$

Which is always the case given the interior solution condition:

$$\alpha - 2g > 0$$

So N is always preferred to M given the subsidy levels required to induce M as a Nash Equilibrium.

APPENDIX 3

Firm 1

$$\pi_N = \left(\frac{\alpha + g + n}{3}\right)^2 + \left(\frac{\alpha - 2g}{3}\right)^2$$

$$\pi_M = \left(\frac{\alpha + n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s)$$

$$N \succ M \text{ if } V - s > \frac{g(2\alpha - 5g - 2n)}{9}$$

$$s_F = V - \frac{4g(\alpha - g)}{9}$$

The statement above now reads

$$\frac{4g(\alpha - g)}{9} > \frac{g(2\alpha - 5g - 2n)}{9}$$

Which holds if

$$2\alpha + g + n > 0$$

Which is always the case given the interior solution condition:

$$\alpha - 2(g + n) > 0$$

So N is always preferred for Firm 1 to M given the subsidy levels required to induce M as a Nash Equilibrium.

Firm 2

$$\pi_N = \left(\frac{\alpha + g}{3}\right)^2 + \left(\frac{\alpha - 2g - 2n}{3}\right)^2$$

$$\pi_M = \left(\frac{\alpha - 2n}{3}\right)^2 + \left(\frac{\alpha}{3}\right)^2 - (V - s_H)$$

$$N \succ M \text{ if } V - s_H > \frac{g(2\alpha - 5g - 8n)}{9}$$

$$s_H = V - \frac{4g(\alpha - g - 2n)}{9}$$

The statement above now reads

$$\frac{4g(\alpha - g)}{9} > \frac{g(2\alpha - 5g)}{9}$$

Which holds if

$$2\alpha + g > 0$$

Which is always the case given the interior solution condition:

$$\alpha - 2(g + n) > 0$$

So N is always preferred for Firm 2 to M given the subsidy levels required to induce M as a Nash Equilibrium.