EVALUATING INVESTMENT PROJECTS IN THE PRESENCE OF SECTORAL LINKAGES: THEORY AND APPLICATION TO TRANSITION ECONOMIES

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Abstract

In this paper we develop a framework to assess the economic impact of foreign investment projects. If investment projects interact with other industries in the host economy, either by buying inputs locally or by selling their own product to local downstream firms, they can create sectoral linkages. The expansion of upstream and downstream industries can feed back to the project’s own industry leading to a further expansion of the local industry. We study the circumstances under which investment projects lead to the creation of sectoral linkages and characterise the factors that determine the project’s welfare impact. We also provide simple charts linking project and industry characteristics to likely project outcomes.

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1. Introduction

This paper addresses the question: how should the economic impact of an investment project in a transition economy be assessed? Classical welfare economics tells us that only under very restrictive circumstances are the narrow financial returns on the project an adequate guide to its economic impact. Traditional cost-benefit analysis goes beyond this by taking into account the effects of price changes caused by the project, and by revaluing inputs and outputs to account for failures of market prices to reflect marginal social valuations.

One difficulty with traditional cost-benefit analysis is that many of the distortions are endogenous; both the gaps between market prices and marginal social valuations, and the quantity changes caused by the project depend in complex ways on the economic environment and the behaviour of agents. This is particularly so in the area of industrial organisation. In sectors in which there are increasing returns to scale, imperfect competition, and input-output links to other similar sectors there may be widespread pecuniary externalities, with changes in one sector influencing another which in turn feeds on (or feeds back) to further sectors.

Inter-industry relationships of this type were extensively studied in the development economics literature of the 1960s - the study of forward and backward linkages between sectors. However, this analysis typically lacked the analytical basis for quantifying the real income implications of such linkages. (And frequently also lacked the conceptual basis for distinguishing between the usual inter-sectoral interactions within an economy and those associated with market imperfections and consequent scope for real income gain). More recent developments provide ways of capturing and quantifying these effects. This project applies these developments to the issue of project appraisal in transition economies.

The project has two parts. First, in this paper, we explore a theoretical model to establish the possible sources of welfare gain, and to identify relevant characteristics of industry structure. And second, in a companion paper we report case studies of ten EBRD financed investment projects. These projects are matched against the results of the theoretical analysis in order to establish whether the predictions from theory are borne out from the actual experience of the projects.
In order to make the match between theory and experience we produce a simple flow chart linking project and industry characteristics to outcomes. The approach seems to be borne out by application to our case studies. We hope that a suitably refined version of the chart may be useful for ex ante project evaluation.

The paper is organised as follows. The next section overviews the theory. Sections 3 and 4 conduct the hypothetical experiments, concentrating on downstream and upstream projects respectively, and synthesise the results into a flow chart. Section 5 concludes. In the companion paper we then present the cases studies, and show, for each study, how the predictions of the flow chart are borne out in reality.

2. Analytical overview

A new investment project will interact with other suppliers in the host economy through the factor market -- competing for factors of production -- and through product markets. We take the simplest possible approach to the factor market interactions, simply assuming that firms and sectors face an infinitely elastic supply of labour and other primary factors. We focus on product markets in greater detail, and look at the interplay of forces for competition and for complementarity between the project under study and other producers.

Competition arises between a project and existing firms to the extent that they supply the same market - where the market has both a geographical dimension (domestic or export) and a commodity dimension (whether the project is in the same market segment as local firms).

The complementarities that we study arise from the supply and demand of intermediate goods -- forward and backward linkages between sectors of the economy. In a perfectly competitive environment such linkages are of no particular significance; intermediates are priced at marginal cost, and changing the quantities in which they are produced is of no social value. But in an imperfectly competitive environment linkages between sectors are of significance because they create pecuniary externalities between the actions of different firms; expanding production of a good sold with price greater than marginal cost is socially valuable. And furthermore, if imperfect competition is modelled
explicitly then we can see how changes in demand and supply may induce changes in the number of active firms, this changing the intensity of competition and the number of varieties produced, and consequently causing price changes which effect other sectors of the economy.

The interaction between these forces can be quite complex as backward and forward linkages have further feedback effects, creating a sort of cumulative causation. For example, a project may cause increased production in a supplier industry (a backward linkage) which may in turn benefit the project and all other firms in the user industry (a forward linkage). To resolve these complexities we develop a theoretical model, which we explore by numerical simulation based on a series of examples. The simulation traces out the effect of the project, and we can establish situations in which an investment project will be more or less beneficial to the host economy.

The analytical model underlying these explorations is relegated to an appendix. Here it is sufficient just to draw attention to a few of its main features. In each case we study there are several industries which are related to each other by an input-output matrix. Each industry is imperfectly competitive, containing distinct firms which operate under increasing returns to scale, produce their own variety of product, and exercise market power, selling at price greater than marginal cost. The number of firms in each industry is, in the initial situation and in the long run, determined by entry and exit in response to profit or loss. While we focus on a single economy, there is also an external rest of the world which may supply imports and demand output from each industry; in this environment trade may be intra-industry, with the economy both importing and exporting goods from the same sector.

We proceed first by looking at a project in a downstream industry, so study the interaction between the competition effect and backwards linkages. We then turn to a project in an upstream industry, in order to analyse the interaction between competition effects and forward links.

3. Investment in a downstream industry

We want to establish the effects of a project in a downstream industry on production and consumption in that industry, and in related industries. It is helpful to proceed in two stages. First, we look at what we call the initial production effect of the project, which consists of the following
elements. Production from the project; the change in production of existing firms (which we refer to as local firms) due to competition from the project (a crowding out effect); and the change in production in supplier industries, as firms in these industries experience changes in demand for their output. In this initial production effect we allow there to be changes in the number of firms operating in the downstream industry, but hold constant the numbers in upstream industries.

Then, we look at the feedback effect. This arises as changes in the upstream industry or industries in turn impact back on the downstream sector, and these are the source of the complementarities in which we are interested. In our model this occurs as entry and exit in the upstream industry change the number of varieties and intensity of competition; other possible mechanisms are also discussed below.

A first - although not entirely satisfactory - look at these effects can be got from simple supply and demand analysis (figure 1). In this figure we focus on the domestic market and assume that there is no foreign trade, so the demand curve is the domestic demand for the downstream product. The initial supply curve $S_0$ is the supply of local producers, in the absence of the project. The project supplies an amount which we call $Ax^P$ to the domestic market, and we assume that the project is at least as efficient as the best local firm, so the supply curve shifts to $S_1$, and a new equilibrium is reached at point $E_1$. The change in production is $Ax^P + Ax^L$, where $Ax^L$ is the change in local production which we can see is negative. Total industry output has increased by less than output from the project -- there has been some crowding out. The initial production effect is this change, $Ax^P + Ax^L$, together with the change in production in upstream industries (which cannot be illustrated on this single market supply and demand curve).

The feedback effects arise as changes in the upstream industry lead to cost and price changes, which in turn change the costs and hence the supply curve in the downstream industry. We discuss details of this mechanism below, but its effect will be to shift the downstream supply curve, to a position such as $S_2$, giving a new equilibrium and output level. Our task now is to be more precise about what determines the magnitude of these effects. We proceed by looking first at the initial production effect, and then at the feedback effect.
3.1 Initial production effect

In figure 2 we analyse what determines the size of the initial production effects in the upstream and downstream industries1.

Consider first the initial production impact in the downstream industry. The size of this effect depends on two key parameters which we call 'relative local supply' and 'local substitutes'. The relative local supply parameter is given on the horizontal axis in figure 2. It measures the ratio of the additional local supply generated by the project relative to the local supply generated by a local firm. Thus, relative local supply depends on both the export orientation of the project and the local firms as well as the extent to which the project is import replacing. Consider first how the respective export orientations affect relative local supply (assume for now that the project is not import replacing). If the local firms and the project both sell equal proportions of their output on the local market, say they only export 20% and sell 80% locally, then relative local supply is unity. But if the project instead only sells 40% locally, then relative local supply is 0.5 (40% divided by 80%), indicating the smaller export orientation of the project. Consider next how the extent to which the project is import replacing affects relative local supply. Take again the case in which the local firms and the project sell equal proportions on the local market. If the project is not import replacing then relative local supply takes the unit value, just as discussed above. If, however, the project is entirely import replacing (the project firm sold the same amount locally before the investment through export to the local market) then relative local supply is zero, the project does not affect the local supply. In general, the more import replacing the project the smaller relative local supply.

The other key parameter in determining the initial production effect in the downstream industry is called ‘local substitutes’. This parameter is an index that measures the presence of local firms in the project industry and can take any value between zero and one. It states the number of units of local

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1 In describing the size of the various effects we concentrate on figures 1 – 5 provided at the end of this paper. In the appendix we also include a matrix as an alternative way of illustrating the size of the linkage effects. While the matrix allows us to include additional parameters we favor using the figures since they are more intuitive and less
sales by local firms that are displaced by one unit of local sales by the project. Hence, if the index takes the value zero then there are no local firms that compete in the same market segment as the project firm. If the index is one then local firms compete in the same market segment as the project.

How do these two parameter, local substitutes and relative local supply, affect the size of the initial production effect in the downstream industry? Assume for now that identical firms are present in the local industry (local substitutes takes value one). If the project does not affect local supply (relative local supply is zero) because either it is entirely import replacing or has a very strong export orientation, then it has no direct effect on the local downstream firms and there is no crowding out. Hence, in this case the initial production effect is just equal to the projects local production. If, instead, the additional local supply generated by the project is just equal to the local sales generated by one local firm (relative local supply is one) then the project causes the exit of exactly one local firm and there is complete crowding out of local production. In this case the initial production effect in the downstream industry is zero, the project does not lead to an increase in local production. This case in which the project is neutral is indicated by the vertical LL-line in figure 2. Note that the initial production effect can also be negative which will be the case if the project is to the right of the vertical LL-line. Suppose, for example, that local firms sell half their output domestically and export half, while the project is not import replacing and sells all its output domestically. In this case relative local supply takes the value two. Each unit output from the project displaces one unit of domestic sales by local firms. But the displacement mechanism is the exit of local firms, which also causes the loss of those firms’ export sales, giving a negative initial production effect. Generally then, the initial production effect in the downstream industry is decreasing in the relative local supply parameter. To the left of the LL-line the initial production effect is positive while to the right it is negative.

The location of the LL-line in figure 2 is therefore crucial in determining the size of the initial production effect. The location is determined by the local substitutes parameter. So far we assumed that there exist local firms that compete in the same market segment as the project, which is to say that we took local substitutes to be equal to one. In this case the LL-line cuts the horizontal axis at unity. If, complex.
however, there are no local firms that compete in the same market segment, so that local substitutes is zero, then there is simply no local production that can be crowded out by the project and the initial production effect is just equal to the project’s local production (the LL-line cuts the horizontal axis in infinity). For an intermediate case suppose that relative substitutes takes the value 0.5 so that each unit of local sales by the project displaces 0.5 units of local sales by local firms. In this case the project is neutral if it generates twice as much local sales as the a local firm so that relative local supply takes the value two. In general then, the LL-line cuts the horizontal axis at the point 1/(local substitutes) just as indicated in figure 2.

Consider next the initial production effect in the upstream industry. The impact of the project on demand for upstream output is captured on the vertical axis which measures relative local sourcing, defined as the project's usage of local inputs per unit output, relative to the usage by local firms. Thus, if the project imports a higher proportion of inputs than do local firms, this ratio will be less than unity.

The upwards sloping line UU is the line along which the project has no effect on the demand for output from the upstream industry, while above the line upstream production increases. The reason for the slope is of course that, even if the project uses few domestic upstream goods, if the project causes little crowding out in the downstream industry (the project is very export oriented, import replacing or competes in a different market segment than local firms so that the initial production impact in the downstream industry is small) then the net effect can be to increase demand for upstream goods. The UU-line always goes through the origin and its slope is given by the value of the local substitutes index. Hence, the lower the local substitutes index the flatter the UU-line and the larger the region in which the initial production effect for both the upstream and the downstream industry is positive.

Putting the LL-line and the UU-line together we can divide the space in four regions. The initial production effect for the downstream industry is increasing in relative local supply. To the left of the LL-line it is positive and to the right it’s negative, independent of relative local sourcing. The initial production effect in the upstream industry is increasing in relative local sourcing and decreasing in relative local supply. Above the LL-line the effect is positive and below it’s negative.
3.2 Feedback effects

This just gives the direct effects of the project on the related industries, and we must now move on to the feedback effects, to see the interaction between sectors. One possibility is that the upstream industry is perfectly competitive, composed of many firms of equal and constant efficiency, and drawing on primary factors which have a constant price. In that case upstream industry expands at constant price and there is no feedback effect. A second possibility is that expansion occurs but causes the price to rise (perhaps because of bidding up the price of scarce upstream industry specific factors of production). There is then a negative feedback effect; any increase in upstream production will raise costs in the downstream industry.

The case on which we want to concentrate is that in which expansion by the upstream industry may reduce the costs of downstream firms. This can arise for a number of reasons. First, there could be direct technical spillovers - downstream firms provide technical assistance with production or quality, and this is not fully internalised, so leads to a reduction in price enjoyed by the downstream industry as a whole. Second, if the upstream industry is imperfectly competitive and firms have downward sloping marginal cost curves, then it is possible that an expansion in their output may lead them to sell at lower cost. Third, the extra demand might attract entry of new firms in the upstream industry, and this will make the industry more competitive. Firms may cut price cost margins in response to the entry, and, if products are differentiated, the entry of new types of upstream products may be of direct value to downstream firms.

Each of these cases means that expansion of the upstream industry (a backwards linkage) has a positive effect on the downstream industry (a forwards linkage). The effects of this are illustrated in figure 3. We see that the line along which downstream output is unchanged, LL, is no longer vertical, but now has positive gradient. This is because at a point such as c the industry experiences a reduction in the cost of its inputs. This causes an expansion in production, so point c is now in the region where both upstream and downstream production increase.

These linkages are important not only for assessing output changes, but also welfare. Anywhere above UU -- ie where output of the upstream industry expands - there is a reduction in the price of
inputs, and hence also a reduction in the price of the downstream product. This is transmitted to consumers, so the price reduction generates a welfare benefit. In other words, whether there is a welfare benefit to consumers (over and above the financial returns to the project) depends on which side of the UU line the project is on.

3.3 Illustrative examples

Some illustrative numbers to illustrate the magnitude of this process are given in table 1, which reports $ changes per $ production by the project.

The first row is a benchmark case, where the project is equally export oriented as local production, in the same market segment, and has the same demand for local intermediates per unit output (these assumptions meaning that the initial production effect is zero and relative local sourcing is unity). First look at the short-run, where there is no entry or exit of any local firms. Competition from the project causes local firms to contract, so $1 production from the project only leads to $0.41 extra output from the downstream industry (d-s) as a whole. This extra downstream output raises upstream production by $0.25. The changes in local firms’ production levels increase profits of upstream firms and reduce them for downstream, with the net loss (-$0.067) reported. There is also price reduction from the extra supply leading to a consumer surplus (c.s.) gain of ($0.24) and hence a net welfare gain of $0.17.

This is short run, insofar as it leaves firms making abnormal profits and losses. The second column gives the initial production effect, so gives what happens when we allow entry and exit to occur in the downstream industry to restore profits to zero. Since the example is constructed with initial production effect of zero and relative local sourcing of unity output in both the downstream and upstream industry is unchanged. Local downstream firms exit, so there is 100% crowding out, and since their sourcing is identical to the projects, there is no change in demand for the upstream product. Consequently, there is no feedback effect -- column 3. This case corresponds to the central point, (0,1), of figures 2 and 3.

Now consider a case in which the project is relatively export oriented, while we maintain the
assumption that it is an equally intensive user of local intermediates as are local firms. Results are given in the second row of the table. Short run effects are more positive on production (although less positive on welfare, as more output is being exported not sold at lower price to domestic consumers). Moving to the initial production effect we see that there is some exit of downstream local firms, but net, an increase in production in the downstream industry; \((Ax^p + Ax^l)/Ax^p = 0.69\). There is also expansion of upstream, \((0.46)\), and we are in the north-east region of figure 2. Allowing entry and exit in the upstream industry, we get the positive feedback effects cutting in. For each $1 output from the project downstream industry production as a whole goes up by $0.88, upstream by $0.79, and, because of the value of the expansion of the upstream industry, consumer surplus and welfare increase by $0.22.

The third experiment is similar, but generates a positive initial production effect not by export orientation, but by placing the project in a different market segment. As in the previous case, there is a positive production impact in both the downstream and upstream industries, and this is magnified once we allow the entry of upstream firms and the positive feedback this creates.

In the fourth row of the table we look at a case where the project is export oriented, but has relative local sourcing of less than unity (a position such as point b in figure 3). We see that the initial production effect in the downstream industry is positive (because of the export orientation) and in the upstream industry is negative (because of the low sourcing of local intermediates). This causes exit of firms from the local upstream industry which -- adding in the feedback effect in column 3 -- means that the change in upstream production becomes smaller. The feedback effect therefore works negatively in this case, and furthermore, because of the higher price index for intermediate goods, there is a welfare reduction.

The final row of the table looks at a case corresponding to point c of figure 3. It has relative local sourcing of greater than unity and local firms relatively more export oriented than the project. The results are as predicted from the figure. The initial production effect is a decrease in production in the downstream industry (because of the project’s low export orientation) and an increase in upstream production (because of the project’s high local sourcing). However, the feedback effect is strong enough to reverse the change in downstream production, so giving a final result in which output from both
sectors expands.

We have so far illustrated the forces at work, and shown how they depend on relative local sourcing (for the linkage) and the initial production effect (capturing direct competition with local firms) effect. We must now relate the strength of these forces to other characteristics of the industries. We do this by discussing a series of numerical examples, derived from simulation of our general model. These are given in table 2. All these examples work with the case in which the project is relatively export oriented, creating a positive production impact, and in which relative local sourcing is unity. This is the case given in row 2 of table 1, and it is reproduced as the first row of table 2 for reference.

### 3.4 Upstream industry characteristics

We change the characteristics of the upstream industry in two dimensions - the extent of imperfect competition, and the openness to international trade.

Rows 2 and 3 of table 2 both make changes to model parameters which have the effect of increasing the degree of imperfect competition in the upstream industry. In row 2 we assume that firms recognise more fully the oligopolistic interaction in the industry, and consequently restrict output somewhat more, setting higher price cost margins. In row 3 we assume that the extent of product differentiation amongst varieties of upstream product is higher, this also having the effect of increasing firms’ market power and raising the price cost margins they set. The main effect of these changes is to make any increase in upstream industry output more valuable - thus, in columns two and three output changes are all similar, but welfare gains are somewhat larger the less competitive is the industry. It also means that the value of the forwards linkage is larger (recall that with a perfectly competitive constant returns upstream industry forward linkages would be valueless), and this accounts for the larger output changes once feedback effects are added (column 3). Looking at the full long run welfare change, we see that this becomes significantly larger as the upstream industry becomes less competitive.

Rows 4 and 5 make the upstream industry more open to trade (although hold the degree of imperfect competition constant). Neither increasing import penetration nor export orientation has very much effect, especially on long run welfare. Essentially, the key variable is the change in the number of
firms in the upstream industry, and openess to trade has little bearing on this. Notice however, that as the number of upstream firms changes, the overall change in upstream output is larger when these firms are more export oriented since they are producing for export as well as for the domestic market.

### 3.5 Downstream industry characteristics

What happens when we do the same experiments with characteristics of the downstream industry?

Rows 6 and 7 change competitive conditions in the downstream industry, making it less competitive (by moving from large group competition to Cournot-Nash behaviour) and by increasing the degree of product differentiation (reducing the elasticity of firms’ demand curves). Moving to Cournot-Nash behaviour causes a very small increase in output responses and welfare gains. The reason is that the project has a pro-competitive effect (through reducing market shares of existing firms and adding a new variety) which encourages output expansion. Increasing the degree of product differentiation has the opposite effect, because it is associated with lower price elasticities of demand, giving smaller quantity responses.

Rows 8 and 9 are like the base case except that they increase the import penetration and export orientation of the downstream industry. In both these cases we see larger output responses. There are two reasons. One is that local industry is less adversely affected by competition from the project, the more open is the industry in the first place. The other is that the scope for output expansion following a reduction in costs (due to forward linkages from the upstream sector) is larger the greater is the potential for reclaiming market share from imports, and for expanding exports. In both these cases the net effect is to give crowding in of local production; complementarities are strong enough that total production per unit output from the project increases by more than unity. This large increase in downstream production pulls with it a large increase in upstream, and hence the large welfare gain of $0.32 per $1 production from the project.

### 3.6 Downstream project: conclusions
The experiments above suggest the following conclusions:

1) *Project characteristics*: The initial production effect of the project is larger:
   - The greater is the export orientation (or import replacement) effect of the project.
   - The more the project is in a market segment distinct from local firms.
   - The greater the usage of local intermediate goods by the project.

2) *Upstream industry characteristics*: The feedback effect is stronger, the greater is the degree of imperfect competition (price cost mark-up) in the upstream industry.

3) *Downstream industry characteristics*: The feedback effect produces greater output expansion and welfare gain:
   - The higher is the elasticity of demand for downstream output.
   - The greater is the potential for expanding sales at the expense of imports.
   - The greater is the potential for expanding export sales.

4. **Investment in an upstream industry**

   We now turn attention to the converse case, where the investment occurs in an upstream industry. Once again, we split analysis into two stages. First, the initial production effect that occurs in response to the project, and then feedback effects from inter-industry linkages. We can start with supply and demand analysis, now looking at the upstream market, rather than the downstream.

   Figure 4, like figure 1, shows the shift in supply curve due to the investment project. Given the demand curve for upstream output, this results in an initial production effect in the upstream industry, as illustrated by the move from \( E_0 \) to \( E_1 \). Associated with this the price of upstream output has fallen, so use of upstream products by the downstream industry increased, the movement along the demand curve \( D_0 \). How do feedback effects now work? The reduction in the price of the upstream good raises profits in the downstream industry, and this attracts entry of downstream firms. In terms of the figure, there is a rotation of the derived demand curve to \( D_2 \), so inducing further output expansion - the feedback effect.

   Two important points need to be noted about this line of argument. First, why do we call this a
feedback effect? We have just made the usual assumption that the long run demand curve is more elastic than the short run. We use this terminology to emphasise the likely complementarity that can arise. Substitution effects mean that a reduction in the price of one sort of intermediate may reduce demand for others; but if it promotes expansion of downstream production then it can increase demand for others, generating a positive feedback across all upstream suppliers.

Second, what happens if the local industry supply curve is perfectly elastic? From the figure, it is evident that the answer is nothing. There is no change in the upstream industry price, and hence no forward linkage and no feedback effect. This points to a significant distinction between backward and forward linkages. With backward linkages it is possible that even if there is no initial production effect in the downstream market there is nevertheless a backward linkage (e.g. relative sourcing not equal to unity) which creates changes in the upstream market and causes a feedback. But with forward linkages, an effect can be transmitted from the upstream market to the downstream only if the price in the upstream changes, i.e. the presence of an initial production effect in the upstream is necessary for there to be changes in the downstream. The competition and linkage effects cannot therefore be separated conceptually in the case of forward linkages as they can be with backwards.

This suggests that in the basic model in which the project competes in the same market segment as the local firms the project cannot generate any forward linkages once we allow for entry and exit in the upstream industry. We can amend the basic model in two main ways to allow for forward linkages. One possibility is that the project does not compete in the same market segment as the local firms (local substitutes is less than one). We have seen above that in this case the project does not lead to full crowding out in the project’s own industry. Hence, as long as local substitutes is less than one the project does lead to a reduction in the price of upstream output and therefore generates a forward linkage. The forward linkage is greater the smaller the local substitutes index.

The model also generates forward linkages if the project is in an intermediate industry that uses inputs produced by a local upstream industry and sells its output to a local downstream industry. We have seen above that such a project generates backward linkages that lead to a price reduction in the upstream industry. We have also seen that this feedback effect is stronger the greater the price cost.
mark-ups in the upstream industry. This price reduction in turn makes the intermediate industry more profitable so that local firms enter the intermediate industry. To the extent that these local firms sell at least a fraction of their output to the local downstream industry this leads to a price reduction for the intermediate industry output generating a forward linkage.

In figure 5 we provide a simple chart to illustrate the likely size of a forward linkage created by an upstream project. As was argued above a project cannot create forward linkages if it competes in the same market segment as local firms, i.e. along the LL – line in figure 5. Note also that, even if firms compete in different market segments, a project cannot create forward linkages if its entire production is exported, i.e. along the VV-line in figure 5. It follows that a project only creates forward linkages if it is located below the LL-line and to the left of the VV-line. The size of the forward linkage is decreasing in the project’s export orientation and the local substitutes index. Hence, the forward linkage is increasing in the direction of the arrow in figure 5.

4.1 Illustrative examples

To proceed further, it is best to see how this works in some illustrative simulations on the model. These are given in table 3.

The first row in the table gives the case in which the project is equally export oriented as local production, and has output in the same market segment as local firms -- and hence regarded by downstream firms as symmetric to that of local firms. In the short run (for a fixed number of local suppliers) there is an increase in production in the upstream industry, this causing an reduction in the price of upstream products, and hence an increase in downstream output and in welfare. However, local firms in the upstream industry are making a loss at this point, so there is exit. This leads us to the initial production effect (column 2), in which there has been 100% crowding out of local firms by the project. Consequently the price of upstream output is unchanged, meaning that there is no forward linkage and no change in downstream production. Moving to the final column, we allow entry and exit in the downstream industry -- but of course, none occurs.

What if we make the project more export oriented than local firms? This case is given in the
second row. In the short run we see a larger expansion in upstream output and small profit loss (local firms are not being forced to contract as much), but smaller downstream expansion and welfare gain, because the domestic price of upstream goods falls less. Letting firms in the upstream industry exit gives the initial production effect. This is positive in the upstream industry, because of the extra export sales from the project. But to restore the local upstream firms’ profits to zero, the price of upstream output must have gone back to its original level, and consequently there is no impact on the downstream industry. Permitting entry and exit in the downstream industry (row 3), nothing happens.

The third row of the table gives a case in which we place the project in a different market segment, so that its output competes less directly with that of local firms. The short run gives the sort of effects that would be expected. The difference arises as we look at the next two columns. Competition from the project causes exit of local firms, but less than in previous cases. This leaves a reduction in the price of upstream output (a price index, combining the price of output from the project with that of local firms), and therefore creates a forward linkage, giving the increase in downstream output (and increase in welfare). When we allow the number of downstream firms to change there is entry, creating a positive feedback effect (column 3); downstream production increases further, as does upstream production and the welfare gain -- a gain of $0.13 for each $1 output from the project.

These examples illustrate how, for a feedback to be present, it is necessary that the project does compete directly with local firms. We shall maintain this assumption in the remainder of this section, as we see what other characteristics of upstream and downstream industries determine the magnitude of the effects.

### 4.2 Downstream industry characteristics

The first row of table 4 reproduces the last of table 3 - our reference for the following experiments. We look first at changes in characteristics of the downstream industry.

Making the downstream industry less competitive (rows 2 and 3, either by switching it to Cournot-Nash competition or by increasing the degree of product differentiation) has a small positive effect on final quantities, and also on welfare gains. The reason is that as the downstream industry
expands so there are pro-competitive effects (reducing prices and price indices) and these are larger the less competitive is the industry in the first place.

Making the downstream industry more open to trade (rows 4 and 5) has the effect of increasing the magnitude of all the quantity responses. The reason is like that we saw in table 2. The downstream industry is affected via a reduction in the price of its inputs, and this cost reduction translates into a larger quantity increase the greater is the potential for expanding sales at the expense of foreigners - either importers or on world export markets. Of course, larger quantity expansion in the downstream industry feeds-back into larger quantity expansion in the upstream, and hence lower intermediate prices and larger welfare gain.

Looking at the upstream industry, row 6 reports the effect of making the industry less competitive. This significantly increases the value of the forward linkages and consequently also output and welfare levels. (We do not simulate a switch to Cournot competition, since the project is now competing in a different market segment). Rows 7 and 8 show the effects of greater upstream industry openness. Higher levels of import penetration increase quantity and welfare effects. The reason is that more of the burden of crowding out is taken by imports, so that local firms have to contract less in face of the project, and fewer exit. Higher levels of exports in the upstream industry have the opposite effect. Since each local firm sells less on the domestic market, more have to be knocked out in the crowding out process, and this mitigates the forward linkage effect.

4.3 Upstream project: conclusions

The experiments above suggest the following conclusions:

1) A necessary condition for gain is that the project leads to a decrease in the price of the upstream output. Since this is also a force for crowding out, a necessary condition for gain is that the project is in a different market segment from local firms.

2) Gains will be larger the more open is the downstream industry to international trade and competition.

3) Gains will be larger the more imperfectly competitive is the upstream industry.
5. Conclusion

In this paper we developed a framework to assess the economic impact of foreign investment projects in the presence of intersectoral linkages. Investment projects can affect local industries in a number of ways. The project's own industry may be directly affected by the presence of a foreign firm through more intensive competition, which may lead to the crowding out of local production. To the extent that the project interacts with local upstream or downstream firms, either by buying inputs locally or by selling its own product to local downstream firms, the project can also create sectoral linkages. The expansion of local upstream or downstream industries can then feed back to the project's own industry leading to a further expansion of the local industry. Using a theoretical model we are able to analyse the various effects and identify a number of project and industry characteristics that determine the likely outcome of investment projects. The analysis is summarised using simple charts.
Table 1: Response to one unit production by project in downstream industry.

<table>
<thead>
<tr>
<th>1: Base: Initial prodn effect = 0; Relative local srcing (rls) = 1</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod: u-s, d-s</td>
<td>0.25, 0.411</td>
<td>Prod: u-s, d-s</td>
<td>0.0, 0.0</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.067, 0.241, 0.174</td>
<td>Profit, c.s, welfare</td>
<td>0.0, 0.0, 0.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2: Project export oriented. (mz = 1.5, rls = 1)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod: u-s, d-s</td>
<td>0.53, 0.82</td>
<td>Prod: u-s, d-s</td>
<td>0.46, 0.69</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0699, 0.0697, 0.140</td>
<td>Profit, c.s, welfare</td>
<td>0.0915, 0.000, 0.0915</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3: Project in separate market segment (sq = 4, rls = 1)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod: u-s, d-s</td>
<td>0.29, 0.58</td>
<td>Prod: u-s, d-s</td>
<td>0.12, 0.29</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.0261, 0.278, 0.251</td>
<td>Profit, c.s, welfare</td>
<td>0.0236, 0.109, 0.132</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4: Project export oriented and low relative local srcing (mz = 1.5, rls=0.125)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod: u-s, d-s</td>
<td>0.01, 0.82</td>
<td>Prod: u-s, d-s</td>
<td>-0.06, 0.69</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.035, 0.070, 0.034</td>
<td>Profit, c.s, welfare</td>
<td>0.013, 0.00, 0.013</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5: Project import oriented and high relative local srcing (mz = 0.9, rls=1.5)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prod: u-s, d-s</td>
<td>0.49, 0.38</td>
<td>Prod: u-s, d-s</td>
<td>0.21, -0.055</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.026, 0.264, 0.238</td>
<td>Profit, c.s, welfare</td>
<td>0.043, 0.00, 0.043</td>
</tr>
</tbody>
</table>
Table 2: Response to one unit production by export oriented project in downstream industry.

<table>
<thead>
<tr>
<th>1: Project export oriented. (mz = 1.5; rls = 1 base in all following)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.53 0.82</td>
<td>0.46 0.69</td>
<td>0.79 0.88</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0699 0.0697 0.140</td>
<td>0.0915 0.000 0.0915</td>
<td>0.0 0.225 0.225</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2: Upstream industry less competition (cn)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.53 0.81</td>
<td>0.46 0.69</td>
<td>0.80 0.89</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0839 0.0702 0.154</td>
<td>0.104 0.00 0.104</td>
<td>0.0 0.231 0.231</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3: Upstream industry less product diff. (sa=4)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.53 0.82</td>
<td>0.46 0.69</td>
<td>0.92 0.99</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0966 0.0697 0.166</td>
<td>0.114 0.000 0.114</td>
<td>0.0 0.347 0.347</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4: Upstream industry more import penetration (hsharea =0.5)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.53 0.82</td>
<td>0.25 0.69</td>
<td>0.79 0.88</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0225 0.0697 0.0921</td>
<td>0.0508 0.000 0.0508</td>
<td>0.0 0.225 0.225</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5: Upstream industry more export oriented (exshare =0.5)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.53 0.82</td>
<td>0.46 0.69</td>
<td>1.1 0.88</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0699 0.0697 0.140</td>
<td>0.0915 0.000 0.0915</td>
<td>0.0 0.225 0.225</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6: Own industry less competition (cnb)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.55 0.83</td>
<td>0.46 0.69</td>
<td>0.80 0.89</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0638 0.0779 0.142</td>
<td>0.0918 0.000 0.0918</td>
<td>0.0 0.226 0.226</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7: Own industry more product diff (sb=sq=4)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.49 0.73</td>
<td>0.34 0.49</td>
<td>0.60 0.64</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0293 0.156 0.185</td>
<td>0.0677 0.000 0.0677</td>
<td>0.0 0.187 0.187</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8: Own industry more import penetration. (hshareb =0.5)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.56 0.90</td>
<td>0.46 0.69</td>
<td>1.0 1.2</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.0915 0.0699 0.161</td>
<td>0.0915 0.000 0.0915</td>
<td>0.0 0.337 0.337</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9: Own industry more export orientation. (exshareb =0.5)</th>
<th>Short run</th>
<th>Initial production effect, no feedback</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.55 0.95</td>
<td>0.52 0.89</td>
<td>1.2 1.6</td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>0.101 0.0178 0.119</td>
<td>0.104 0.000 0.104</td>
<td>0.0 0.323 0.323</td>
</tr>
</tbody>
</table>
Table 3: Response to one unit production by project in upstream industry.

<table>
<thead>
<tr>
<th></th>
<th>Short run</th>
<th>Initial production effect, no feedback.</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1: Base</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.38</td>
<td>0.073</td>
<td></td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.099</td>
<td>0.238 0.138</td>
<td></td>
</tr>
<tr>
<td><strong>1: Project more export oriented</strong> (mz=1.5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.81</td>
<td>0.021</td>
<td></td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.032</td>
<td>0.068 0.037</td>
<td></td>
</tr>
<tr>
<td><strong>2: Imperfect substitutes</strong> (sq=4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prodn: u-s, d-s</td>
<td>0.55</td>
<td>0.084</td>
<td></td>
</tr>
<tr>
<td>Profit, c.s, welfare</td>
<td>-0.0630</td>
<td>0.274 0.211</td>
<td></td>
</tr>
</tbody>
</table>
Table 4: Response to one unit production by project in upstream industry in distinct market segment.

<table>
<thead>
<tr>
<th></th>
<th>Short run</th>
<th>Initial production effect, no feedback.</th>
<th>Full effect, with feedback</th>
</tr>
</thead>
</table>
| **1: Imperfect substitutes**  
sq=4 (in all following) | u-s, d-s  
0.55 0.084  
Profit, c.s, welfare -0.0630 0.274 0.211 | u-s, d-s  
0.27 0.032  
Profit, c.s, welfare 0.0104 0.103 0.113 | u-s, d-s  
0.29 0.067  
Profit, c.s, welfare 0.0 0.126 0.126 |
| **2: Downstream industry**  
less competition (cn) | u-s, d-s  
0.55 0.085  
Profit, c.s, welfare -0.0593 0.272 0.213 | u-s, d-s  
0.27 0.032  
Profit, c.s, welfare 0.0119 0.102 0.114 | u-s, d-s  
0.29 0.069  
Profit, c.s, welfare 0.0 0.126 0.126 |
| **3: Downstream industry**  
more product diff.  
(sc=4) | u-s, d-s  
0.55 0.074  
Profit, c.s, welfare -0.0592 0.274 0.215 | u-s, d-s  
0.27 0.028  
Profit, c.s, welfare 0.0121 0.102 0.114 | u-s, d-s  
0.32 0.13  
Profit, c.s, welfare 0.0 0.146 0.146 |
| **4: Downstream industry**  
more import penetration  
(hsharec =0.5) | u-s, d-s  
0.57 0.087  
Profit, c.s, welfare -0.0629 0.275 0.212 | u-s, d-s  
0.29 0.034  
Profit, c.s, welfare 0.0093 0.106 0.115 | u-s, d-s  
0.32 0.18  
Profit, c.s, welfare 0.0 0.138 0.138 |
| **5: Downstream industry**  
more export oriented  
(exsharec =0.5) | u-s, d-s  
0.55 0.15  
Profit, c.s, welfare -0.0465 0.256 0.209 | u-s, d-s  
0.27 0.058  
Profit, c.s, welfare 0.0167 0.0956 0.112 | u-s, d-s  
0.47 0.13  
Profit, c.s, welfare 0.0 0.251 0.251 |
| **6: Upstream industry**  
less competition (sb=4, sq=3) | u-s, d-s  
0.68 0.11  
Profit, c.s, welfare -0.043 0.379 0.335 | u-s, d-s  
0.44 0.063  
Profit, c.s, welfare 0.0205 0.204 0.224 | u-s, d-s  
0.47 0.13  
Profit, c.s, welfare 0.0 0.251 0.251 |
| **7: Upstream industry**  
more import penetration.  
(hshareb =0.5) | u-s, d-s  
0.76 0.072  
Profit, c.s, welfare -0.0251 0.234 0.209 | u-s, d-s  
0.48 0.036  
Profit, c.s, welfare 0.0118 0.115 0.127 | u-s, d-s  
0.49 0.075  
Profit, c.s, welfare 0.0 0.141 0.141 |
| **8: Upstream industry**  
more export orientation.  
(exshareb =0.5) | u-s, d-s  
0.66 0.063  
Profit, c.s, welfare -0.0474 0.206 0.159 | u-s, d-s  
0.24 0.024  
Profit, c.s, welfare 0.00800 0.0787 0.0867 | u-s, d-s  
0.26 0.051  
Profit, c.s, welfare 0.0 0.0963 0.0963 |
Appendix: Parameter values used in the model:

Base case of table 1: parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>na-nb-nm-naf-nbf-ncf</td>
<td>4.0000 4.0000 4.0000 0.00000 0.44444 0.44444 0.44444</td>
</tr>
<tr>
<td>sa-sb-sc-sq-eta-etb-etc</td>
<td>5.0000 5.0000 5.0000 5.0000 2.0000 2.0000 2.0000</td>
</tr>
<tr>
<td>ya-yb-ya-za-zb-zc-zm</td>
<td>100.00 100.00 100.00 3.3638 2.2500 2.2500 2.2500</td>
</tr>
<tr>
<td>ya-yb-ya-za-zb-zc-zm</td>
<td>100.00 100.00 100.00 3.3638 2.2500 2.2500 2.2500</td>
</tr>
<tr>
<td>am-bm-cm</td>
<td>0.00000 0.50000 0.00000</td>
</tr>
<tr>
<td>ba-bb-bc</td>
<td>0.00000 0.00000 0.00000</td>
</tr>
<tr>
<td>ca-cb-cc</td>
<td>0.00000 0.00000 0.00000</td>
</tr>
<tr>
<td>am-bm-cm</td>
<td>0.50000 0.00000 0.00000</td>
</tr>
<tr>
<td>mz-cn</td>
<td>1.0000 0.00000</td>
</tr>
</tbody>
</table>

INITIAL LONG RUN

| check | -1.1369e-013 |
| na-nb-nm | 4.0000 4.0000 4.0000 0.00000 |
| xa-xb-xc-xm | 33.637 22.500 22.500 22.500 |
| ka-kb-kc-km | 0.80000 0.80000 0.80000 0.80000 |
| qa-qbm-qc | 1.0000 1.0000 0.70711 1.2247 1.0000 |
| (dom a, b, c/mult)/sales | 0.90000 0.90000 0.90000 0.00000 |
| export/prodn | 0.10000 0.10000 0.10000 0.10000 |
| cs, sales, prodn | 300.00 300.00 346.00 |
Appendix: Outline of the formal model

The model is outlined informally in the paper, and here we present a brief statement of the equations.

1) Production sectors: There are three sectors, a, b, and c. Each sector can be supplied by local firms (the numbers of which are denoted \(n_a, n_b, n_c\), selling at prices \(p_a, p_b, p_c\)) and foreign firms (numbers denoted \(n^f_a, n^f_b, n^f_c\) and prices \(p^f_a, p^f_b, p^f_c\)). In addition, industry b can be supplied by output from the particular project that we wish to study; it is convenient to denote the ‘number of firms’ in the project \(n_m^b\), (though this will be set at unity), and its output price \(p_m^b\).

2) Demand: All these potential suppliers produce differentiated products, demands for which come from constant elasticity of substitution expenditure functions. For industries a and c these take the form,

\[
G^a = \left[ n_a^a \left( p_a^a \right)^{1/\sigma_a} + n^f_a \left( p^f_a \right)^{1/\sigma_a} \right]^{1/(1/\sigma_a)}
\]

\[
G^c = \left[ n_c^c \left( p_c^c \right)^{1/\sigma_c} + n^f_c \left( p^f_c \right)^{1/\sigma_c} \right]^{1/(1/\sigma_c)}
\]

so \(\sigma_a\) is the elasticity between a pair of varieties in the a industry. For industry b we take a more complex two level structure,

\[
G^b = \left[ (G_d^b)^{1-\sigma} + (G_f^b)^{1-\sigma} \right]^{1/(1-\sigma)}
\]

where
This formulation says that the elasticity between any pair of varieties produced by local firms is $\sigma^b$, and so too is the elasticity between any pair produced by foreign firms or project firms. However, the elasticity between products from these two sets of firms may be different. In particular, we shall sometimes take $\sigma < \sigma^b$ to capture the idea that project (and foreign) firms are in a different market segment from national firms in the same industry. If $\sigma = \sigma^b$ then symmetry is restored.

Given these expenditure functions we derive the following demand functions for the domestic sales, $x^j_i$, of firms of each type:

\[
G^b_d = \left[ n^b_d \left( p^b_d \right)^{1-\sigma^b} \right]^{1/(1-\sigma^b)}
\]

\[
G^b_f = \left[ n^b_f \left( p^b_f \right)^{1-\sigma^b} + n^b_m \left( p^b_m \right)^{1-\sigma^b} \right]^{1/(1-\sigma^b)}
\]

These demands depend on prices, competition from other firms (as summarised in the price indices) and expenditure levels. $G^j Y^i$ is final domestic expenditure on goods from industry $j$, assumed to be
exogenous, and \( I^j \) is domestic expenditure on industry \( j \) for intermediate use, derived below.

In addition to these domestic demands, firms can sell in export markets. They face demand functions,

\[
\begin{align*}
Z^a_d &= \left( q^a_d \right)^{a^a} Z^a \\
Z^c_d &= \left( q^c_d \right)^{a^c} Z^c \\
Z^b_d &= \left( q^b_d \right)^{a^b} Z^b \\
Z^b_m &= \left( q^b_m \right)^{a^b} Z^b
\end{align*}
\]

where \( q^j_i \) is the export price, \( z^j_i \) the quantity demanded, and \( Z^j \) the exogenous position of the export demand curve

3) Technology: Local production is undertaken by domestic firms and the project, \( n^a_d, n^b_d, n^b_m, n^c_d \).

Their technologies are described by cost functions,

\[
\begin{align*}
K^a_d &= k^a_d \left( G^a_d \right)^{a^a} \left( G^b_d \right)^{a^b} \left( G^c_d \right)^{a^c} \left( x^a_d + z^a_d + F^a_a \right) \\
K^c_d &= k^c_d \left( G^a_d \right)^{a^c} \left( G^b_d \right)^{b^c} \left( G^c_d \right)^{c^c} \left( x^c_d + z^c_d + F^c_d \right) \\
K^b_d &= k^b_d \left( G^a_d \right)^{a^b} \left( G^b_d \right)^{b^b} \left( G^c_d \right)^{c^b} \left( x^b_d + z^b_d + F^b_d \right) \\
K^b_m &= k^b_m \left( G^a_d \right)^{a_m} \left( G^b_m \right)^{b_m} \left( G^c_m \right)^{c_m} \left( x^b_m + z^b_m + F^b_m \right)
\end{align*}
\]

These say that fixed costs \( F^j \) and production of output \( x^j + z^j \) both use a composite input. This is formed as a Cobb-Douglas function of intermediate goods, with price \( G^j \) and share \( ij \), and of the primary factor, with price unity. \( k^j_i \) is a constant. Given this input-output structure we can express the value of intermediate demand for each good as:

\[
I^a = (aa)n^a_d K^a_d + (ac)n^c_d K^c_d + (ab)n^b_d K^b_d + (am)n^b_m K^b_m
\]
\[ I^b = (ba)n_d^a K_d^a + (bc)n_d^c K_d^c + (bb)n_d^b K_d^b + (bm)n_m^b K_m^b \]

\[ I^c = (ca)n_d^a K_d^a + (cc)n_d^c K_d^c + (cb)n_d^b K_d^b + (cm)n_m^b K_m^b \]

4: Firm behaviour: Firms set up price by a mark up over marginal cost which depends on perceived elasticity of demand. In export markets this is simply the slope of the demand that comes from product differentiation, so

\[ q_d^a = k_d^a(G^a f^{a}(G^b)^{ba}(G^c)^{ca}(1 - 1/\sigma^a)) \]

\[ q_d^c = k_d^c(G^a f^{ac}(G^b)^{bc}(G^c)^{cc}(1 - 1/\sigma^c)) \]

\[ q_d^b = k_d^b(G^a f^{ab}(G^b)^{bb}(G^c)^{cb}(1 - 1/\sigma^b)) \]

\[ q_m^a = k_m^a(G^a f^{am}(G^b)^{bm}(G^c)^{cm}(1 - 1/\sigma^b)) \]

In the domestic market we allow for the possibility of strategic interaction between firms. If this is Cournot, then

\[ p_d^a \left[ 1 - \frac{1}{\sigma^a(I - s_d^a) + \eta^a s_d^a} \right] = k_d^a(G^a f^{aa}(G^b)^{ba}(G^c)^{ca}) \]

\[ p_d^c \left[ 1 - \frac{1}{\sigma^c(I - s_d^c) + \eta^c s_d^c} \right] = k_d^c(G^a f^{ac}(G^b)^{bc}(G^c)^{cc}) \]

\[ p_d^b \left[ 1 - \frac{1}{\sigma^b(I - s_d^b) + \eta^b s_d^b} \right] = k_d^b(G^a f^{ab}(G^b)^{bb}(G^c)^{cb}) \]

\[ p_m^b \left[ 1 - \frac{1}{\sigma^b(I - s_m^b) + \eta^b s_m^b} \right] = k_m^b(G^a f^{am}(G^b)^{bm}(G^c)^{cm}) \]

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where $s_i^j$ is the share of a single firm of type $i$ in the domestic market for product $j$.

The final ingredient is that the number of domestic firms adjusts to zero profits, i.e. where revenue from domestic and export sales equals costs.

5. **Calibration and simulation:** The model is solved for different values of expenditures levels, setting $Y^j$ and $Z^j$ to position demand curves, and of costs, setting $k_i^j$. These choices determine the equilibrium sales and market shares of the different firms. We investigate equilibria with different values of the input output coefficients (often setting entire rows and columns equal to zero, so that one industry becomes independent of the others), with the Cournot and large group assumptions (in the latter case market shares $s_i^j$ in equation (14) are set equal to zero), and with different values of the elasticities of substitution.
References


Markusen, J. R. and A J. Venables (1997), >The impact of foreign direct investment on host economies= processed, LSE.