

# EVALUATING INVESTMENT PROJECTS IN THE PRESENCE OF SECTORAL LINKAGES\*

Niko Matouschek  
Northwestern University

Tony Venables  
London School of Economics

## 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 link analytical findings to case studies undertaken for the EBRD.

Keywords: foreign investment projects, sectoral linkages, economic development

JEL classifications: O12, O22, F23

---

\*We would like to thank Mark Schankerman and two anonymous referees for very useful comments.

## 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 work typically lacked the analytical basis for quantifying the real income implications of such linkages. Also, it frequently 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.<sup>2</sup> More recent developments provide ways of capturing and quantifying these effects. This paper applies these developments to the issue of project appraisal in transition economies.<sup>3</sup> In particular we explore a theoretical model to establish the possible sources of welfare gain, and to identify relevant characteristics of industry structure. In a companion paper (Matouschek and Venables 1999) 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

---

2 A good discussion is contained in chapter 16 of Little and Mirrlees (1968). They argue that linkage effects are unlikely to be large, and that where they are, interlinked projects (refrigerators and electric motors in their example) should be appraised as a whole, rather than separately.

3 The linkage effects that are central to our analysis are likely to be particularly important in transition economies since in such economies investment projects can be very large and local firms often exist in upstream and downstream industries. However, in general the analysis can also be applied to investment project in less developed- and developed economies.

the predictions from theory are borne out from the actual experience of the projects. We provide an overview of these case studies in Section 6 below.<sup>4</sup> In order to make the match between theory and experience we produce a simple classification linking project and industry characteristics to outcomes. 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. Section 3 lays out the formal model, and Sections 4 and 5 investigate the implications of downstream and upstream investments respectively. Finally, Section 6 concludes.

## **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 since intermediates are priced at marginal cost and changing the quantities in which they are produced is of no social value. In an imperfectly competitive environment, however, linkages between sectors are of significance because they create pecuniary externalities between the actions of different firms. For instance, expanding the production of a good sold with price greater than marginal cost is socially valuable. Furthermore, if imperfect competition is modelled explicitly, then we can see how changes in

---

<sup>4</sup> The current paper and Matouschek and Venables (1999) were part of a consulting project that the authors performed for the EBRD. Since Matouschek and Venables (1999) contains confidential company information it is not publicly available.

demand and supply may induce changes in the number of active firms, thus 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 is based on the Dixit-Stiglitz (1977) model of monopolistic competition, and its extensions particularly in the work of Rodriguez-Clare (1996), Markusen and Venables (1999), Fujita et al (1999) and Baldwin et al (2003). Here the model is disaggregated to 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.

### 3. The Model

We describe the model in four steps: first the production sectors, then the demand side, the production technology, and finally firm behaviour.

**Production sectors:** There are two sectors,  $a$  and  $b$ . Each sector,  $i = a, b$ , can be supplied by  $n_L^i$  local firms selling at prices  $p_L^i$ , and by imports from  $n_f^i$  foreign firms, selling at prices  $p_f^i$ . The particular project under study operates in industry  $b$ . Project specific variables carry subscript  $m$  (as compared to  $L$  for local firms and  $f$  for foreign ones), so the project sets price denoted by  $p_m^b$ . It is

convenient to denote the ‘number of firms’ in the project by  $n_m^b$ , though this will be set at zero or unity.

**Demand:** All these potential suppliers produce differentiated products, demands for which come from constant elasticity of substitution expenditure functions. For industry  $a$  this takes the form,

$$G^a = \left[ n_L^a (p_L^a)^{1-\sigma^a} + n_f^a (p_f^a)^{1-\sigma^a} \right]^{1/(1-\sigma^a)}. \quad (1.1)$$

$G^a$  is the unit expenditure function, or price index, and  $\sigma^a$  is the elasticity between a pair of varieties in the  $a$  industry; we assume that this (and similar elasticities in industry  $b$ ) is greater than unity. For industry  $b$ , where the project is located, we take a more complex two level structure,

$$G^b = \left[ (G_L^b)^{1-\sigma} + (G_f^b)^{1-\sigma} \right]^{1/(1-\sigma)}, \quad (1.2)$$

where

$$G_L^b = \left[ n_L^b (p_L^b)^{1-\sigma^b} \right]^{1/(1-\sigma^b)} \quad (1.3)$$

and

$$G_f^b = \left[ n_f^b (p_f^b)^{1-\sigma^b} + n_m^b (p_m^b)^{1-\sigma^b} \right]^{1/(1-\sigma^b)}. \quad (1.4)$$

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,  $\sigma$ , 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 local 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,  $x_i^j$ , of firms of each type:

$$x_L^a = (p_L^a / G^a)^{\sigma^a} \left[ Y^a (G^a)^{-\eta^a} + I^a / G^a \right], \quad (2.1)$$

$$x_f^a = (p_f^a / G^a)^{\sigma^a} \left[ Y^a (G^a)^{-\eta^a} + I^a / G^a \right], \quad (2.2)$$

$$x_L^b = (p_L^b / G_L^b)^{\sigma^b} (G_L^b / G^b)^{\sigma} \left[ Y^b (G^b)^{-\eta^b} + I^b / G^b \right], \quad (2.3)$$

$$x_f^b = (p_f^b / G_f^b)^{\sigma^b} (G_f^b / G^b)^{\sigma} \left[ Y^b (G^b)^{-\eta^b} + I^b / G^b \right], \quad (2.4)$$

and

$$x_m^b = (p_m^b / G_m^b)^{\sigma^b} (G_m^b / G^b)^{\sigma} \left[ Y^b (G^b)^{-\eta^b} + I^b / G^b \right]. \quad (2.5)$$

These demands depend on prices, competition from other firms – as summarised in the price indices – and expenditure levels.  $Y^j$  is final domestic expenditure on goods from industry  $j$ , assumed to be exogenous, and  $\eta^j$  is the elasticity of final demand with respect to the price index for the sector as a whole.  $I^j$  is domestic expenditure on industry  $j$  for intermediate use, derived below.

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

$$z_L^a = (r_L^a)^{-\sigma^a} Z^a, \quad z_L^b = (r_L^b)^{-\sigma^b} Z^b, \quad z_m^b = (r_m^b)^{-\sigma^b} Z^b, \quad (3.1)$$

where  $r_i^j$  is the export price,  $z_i^j$  the quantity demanded, and  $Z^j$  the exogenous position of the export demand curve.

**Technology:** Local production is undertaken by domestic firms and the project. Their technologies are described by the total cost functions

$$K_L^a = k_L^a (G^a)^{a_a} (G^b)^{b_a} (x_L^a + z_L^a + F_L^a), \quad (4.1)$$

$$K_L^b = k_L^b (G^a)^{a_L} (G^b)^{b_L} (x_L^b + z_L^b + F_L^b), \quad (4.2)$$

and

$$K_m^b = k_m^a (G^a)^{a_m} (G^b)^{b_m} (x_m^b + z_m^b + F_m^b). \quad (4.3)$$

These expressions say that fixed costs,  $F_i^j$ , and production of output,  $(x_i^j + z_i^j)$ , both use a composite input. This composite is formed as a Cobb-Douglas function of intermediate goods, with prices  $G^j$  and input shares given by the exponent on the corresponding price index. They also use labour, which has price unity;  $k_i^j$  is a constant. Given this input-output structure we can express the value of intermediate demand for each good as:

$$I^a = a_a n_L^a K_L^a + a_L n_L^b K_L^b + a_m n_m^b K_m^b \quad (5.1)$$

and

$$I^b = b_a n_L^a K_L^a + b_L n_L^b K_L^b + b_m n_m^b K_m^b. \quad (5.2)$$

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

$$r_L^a (I - I/\sigma^a) = k_L^a (G^a)^{a_L} (G^b)^{b_a}, \quad (6.1)$$

$$r_L^b (I - I/\sigma^b) = k_L^b (G^a)^{a_L} (G^b)^{b_L}, \quad (6.2)$$

and

$$r_m^a (I - I/\sigma^b) = k_m^a (G^a)^{a_m} (G^b)^{b_m}. \quad (6.3)$$

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

$$p_L^a \left[ I - \frac{I}{\sigma^a (I - s_L^a) + \eta^a s_L^a} \right] = k_L^a (G^a)^{a_L} (G^b)^{b_a}, \quad (7.1)$$

$$p_L^b \left[ I - \frac{I}{\sigma^b (I - s_L^b) + \eta^b s_L^b} \right] = k_L^b (G^a)^{a_L} (G^b)^{b_L}, \quad (7.2)$$

and

$$p_m^b \left[ I - \frac{I}{\sigma^b (I - s_m^b) + \eta^a s_m^b} \right] = k_m^b (G^a)^{a_m} (G^b)^{b_m}, \quad (7.3)$$

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, in the long run, the numbers of local firms,  $n_L^a$  and  $n_L^b$ , adjust to the value at which zero profits are earned, i.e. where revenue from domestic and export sales equals costs.

With this general framework in place we are now in a position to investigate first, what happens when the project is in a downstream industry. In this case industry  $b$  is downstream, so its output is not used as in input to production and the technology coefficients are  $b_a = b_L = b_m = 0$ . Industry  $a$  is upstream, supplying inputs to local firms and to the project in industry  $b$ , so  $a_L$  and  $a_m$  are positive. we assume that it does not supply inputs to itself, so  $a_a = 0$ . In Section 5 we turn to the

case where industry  $b$  is upstream and industry  $a$  downstream. The only non-zero input-output coefficient is then input of  $b$  per unit output of  $a$ ,  $b_a > 0$ .

#### **4. Investment in a Downstream Industry**

In this section we analyze the effects of an investment in the downstream industry. We first provide an intuitive description of the main effects using simple graphs. In sub-section 3.2 we then use numerical simulations to gain a better understanding of the factors that determine the magnitude of the different effects.

##### **4.1 Initial Production- and Feedback Effects**

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: (i) production from the project, (ii) the change in production of local firms due to competition from the project – a crowding out effect, and (iii) 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 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 gotten 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  $S_o$  is the supply of local producers, in the absence of the project. The project supplies an amount  $AB$  to the domestic market. Since we assume that the project is at least as efficient as the best local firm the supply curve shifts to  $S_I$  and a new equilibrium is reached



at point  $E_1$ . The change in production is  $CD$ , less than  $AB$  with the difference being the crowding out of some local production. Total industry output has increased by less than output from the project because of this crowding out. The *initial production effect* is this change,  $CD$ , 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 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.

#### 4.1.1 Initial production effect

We want to identify the changes in each industries' output that are triggered by the project. The value of the output produced by the project is  $dQ_m^b = (p_m^b x_m^b + r_m^b z_m^b) dn_m^b$ , while the direct change in local sales is  $dX_m^b = p_m^b x_m^b dn_m^b + d(p_f^b x_f^b n_f^b)$ . Production and local sales of the project differ both because the project may export, and because it may be import replacing.<sup>5</sup> The initial production effect in the downstream industry is  $dQ_m^b + dQ_L^b$ , i.e. the output of the project plus any induced change in production of local firms in the same industry,  $dQ_L^b$ . The initial production effect in the upstream industry is driven by the change in derived demand, so  $dQ_L^a = a_m dQ_m^b + a_L dQ_L^b$ , where  $a_m$  and  $a_L$  are the value shares of intermediates from industry  $a$  used by the project and by local firms in industry  $b$ ; we assume for the moment that there are no intermediate imports.

To investigate the initial production- and feedback effects we define *relative local supply* as  $\alpha \equiv (dX_m^b / dQ_m^b) / (dX_L^b / dQ_L^b)$ , where  $dX_L^b / dQ_L^b$  is the change in the sales of local firms relative to

---

5 For example, the firm may have previously imported and now becomes a local producer.

their change in production and is given by  $dX_L^b/dQ_L^b = p_L^b x_L^b / (p_L^b x_L^b + r_L^b z_L^b)$ .<sup>6</sup> Thus, *relative local supply* measures the extent to which output from the project creates local sales – rather than exports or import displacement – expressed relative to the ratio of local sales to the production of local firms. We also define *relative local sourcing* as  $a_m / a_L$ , the ratio of the technology coefficients for the project and local owned plants. Thus, for example, *relative local sourcing* will be less than unity if the project is more dependent on local imports than are local firms.

Finally, we define *local substitutability* as  $\beta \equiv (dX_L^b / dX_m^b)$ . This gives the value of sales by local firms that are displaced by one unit of sales by the project. Hence, if the index takes the value zero there are no local firms that compete in the same market segment as the project, and if the index is one, then local firms compete one-to-one in the same market segment as the project. An expression for  $\beta$  can be derived from the model as follows. The project increases supply to the local market, this reducing price indices  $G_f^b$  and  $G^b$  and hence reducing the sales of local firms (equation (2.3)). We suppose that the local industry is in initial long run zero profit equilibrium, so the associated reduction in profits induces a change in the number of firms,  $dn_L^b$ . For our benchmark case we employ the ‘large group assumption’, so that firms set a constant price cost mark-up (they act as if they have zero market shares in the pricing equations (7)) and therefore break even when they reach a given level of sales. Thus, once long run adjustment is complete,  $dx_L^b = 0$ . Totally differentiate (2.3) and price indices (1) and using this condition in order to find the change  $dn_L^b$  and hence an expression for  $\beta$ . If  $\eta^b = 1$  this takes the form,

$$\beta \equiv dX_m^b / dX_f^b = \lambda(1 - \sigma) / [\sigma^b - \sigma - \lambda(1 - \sigma)], \quad (8)$$

where  $\lambda$  is the share of local firms in local sales. To interpret this expression, note that if  $\sigma = \sigma^b$  then  $\beta = -1$ . In this case the project and local firms are producing in the same market segment and there is 100% crowding out. Reducing the parameter  $\sigma$  lowers the degree of substitutability between local firms’ products and other products in industry  $b$ , and reduces the absolute value of  $\beta$ .

---

6 Note that the average is the same as the marginal, i.e.  $X_L^b / Q_L^b = n_L^b p_L^b x_L^b / (n_L^b p_L^b x_L^b + n_L^b r_L^b z_L^b) = dX_L^b / dQ_L^b$ , since adjustment occurs through entry or exit of symmetric firms (the number of which,  $n_L^b$ , cancels out of this expression).

If  $\sigma = 1$ , then expenditures on local firms sales are constant, so crowding out goes to zero.

Using the concepts of relative local supply, relative local sourcing and local substitutability we can express the initial production effect of the project as

$$\left(dQ_m^b + dQ_L^b\right) / dQ_m^b = 1 + \alpha\beta \quad \text{and} \quad dQ_L^a / dQ_m^b = a_L [a_m / a_L + \alpha\beta]. \quad (9)$$

Consider now Figure 2, in which the horizontal axis is relative local supply,  $\alpha$ . If  $\alpha$  were zero – as would be the case if the project simply produced goods that were previously imported or exported all its output – then production in the downstream industry would certainly be increased by the project. If  $\alpha$  were strictly positive, however, the positive direct effect that the project has on sales in the local market may be partly offset by the crowding out of local firms. The net effect on downstream production then depends on relative local supply  $\alpha$  relative to local substitutability  $\beta$ . The net effect is zero along the line  $bb$  on which  $\alpha = -1/\beta$ .

The vertical axis measures relative local sourcing, the ratio  $a_m / a_L$ . It follows from (8) that the net effect of the project on upstream production depends on this ratio relative to  $\alpha\beta$ . In particular, the net effect is zero if  $a_m / a_L = -\alpha\beta$ , positive if  $a_m / a_L < -\alpha\beta$ , and negative otherwise.

In terms of Figure 2, the net effect of upstream production is zero along the line  $aa$  and it is positive above this line and negative below it. It can be seen that in the bottom left region upstream output falls in spite of the increase in downstream production. This can only happen because the project is a less intensive user of locally produced intermediates than is local production.

Putting the  $bb$ -line and the  $aa$ -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  $bb$ -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  $bb$ -line the effect is positive and below it is negative.

#### 4.1.2 Feedback effects

Having considered the direct effects of the project on the related industries we must now move on to the feedback effects, to see the interaction between sectors. We suppose that the upstream industry is initially in long run equilibrium. Any change in its sales,  $dQ_L^a$ , changes firms'

profitability, so causing entry or exit (a change in the number of firms,  $dn_L^a$ ) until profits are restored to zero. The magnitude of this effect can be found, in principle, by total differentiation of the model. Given a change in the number of firms in the upstream industry, the value of this for the downstream industry comes through its impact on the price index,  $G^a$ , which enters downstream firms' costs. An increase in  $n_L^a$  reduces the price index,  $G^a$ , through two mechanisms. One is a variety effect; entry of a new upstream variety brings with it some economic surplus, this being greater the lower is  $\sigma^a$ . The other is a price effect; if entry reduces the market share of each single firm and firms are interacting oligopolistically, as in the Cournot pricing rules of equations (7), then there is an increase in intensity of competition in the upstream industry that reduces price-cost margins. Thus, the expansion of the upstream industry (a backward linkage) has a positive effect on the downstream industry (a forward linkage).<sup>7</sup>

The effects of this are illustrated by the dashed line  $bb'$  in Figure 2. The rotation of  $bb$  occurs because, even though there is no direct production effect on downstream output, there is an indirect effect via the expansion or contraction of upstream production and consequent feedback. Thus, at a point such as  $c$  the downstream industry experiences a reduction in the cost of its inputs. This causes an expansion in production, so point  $c$  is in the region where both upstream and downstream production increase.

## 4.2 Numerical Simulations

So far we have outlined the main mechanisms in the model and their interaction. Some of the key parameters – such as relative local supply – can only be derived from direct inspection of the project. Others – such as local substitutability and the magnitude of feedback effects – come from interactions within the industries. To pin these down and to investigate the determinants of the

---

<sup>7</sup> There are reasons other than entry of firms for why an expansion by the upstream industry may reduce the costs of downstream firms. 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 firms in the downstream industry. Alternatively, in the absence of imperfect competition or these spillovers, upstream expansion could have a zero or negative effect on the costs of the downstream firms. If the upstream industry is perfectly competitive, composed of firms of equal and constant efficiency, and draws on primary factors which have a constant price, then upstream industry expansion occurs at constant price and there is no feedback effect. If the expansion causes input prices to rise (e.g. bidding up the price of scarce upstream industry specific factors of production) then there is a negative feedback effect; an increase in upstream production will raise costs in the downstream industry.

magnitude of the effects, we now turn to numerical simulations of the model.

#### 4.2.1 Illustrative Examples

We now perform numerical simulations to get a better understanding for the factors that determine the magnitude of the initial production- and feedback effects. We first investigate the effects of changes in the project characteristics, such as export orientation and the extent of local sourcing, holding constant the characteristics of the upstream- and downstream industries, such as the degree of imperfect competition and the openness to trade. We then investigate the effects of changes in the industry characteristics, holding constant the project characteristics.

**Project Characteristics:** Consider 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 ( $\alpha = 1$ ), in the same market segment ( $\beta = -1$ ), and has the same demand for local intermediates per unit output ( $a_m / a_L = 1$ ) (see appendix for parameter values). We also assume large group competition (so price-cost mark-ups are derived purely from product differentiation) unless otherwise stated. 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 ( $b$ ) industry 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 firms, with net loss for local firms, (-\$0.067). There is also a 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 the short run, insofar as it leaves firms making abnormal profits and losses. The second column gives the initial production effect, i.e. it tells us what happens when we allow entry and exit to occur in the downstream industry but not in the upstream industry. Since the example is constructed with relative local supply and relative local sourcing of unity and with local substitutability of minus one, 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, as can be seen in column 3.

Now consider a case in which the project is relatively export oriented ( $\alpha < 1$ ), while we maintain the assumption that it is an equally intensive user of local intermediates as are local firms ( $a_m / a_L = 1$ ) and is in the same market segment ( $\beta = -1$ ). 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 rather than being 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;  $(dQ_m^b + dQ_L^b) / dQ_m^b = 0.69$ . There is also expansion of upstream production,  $dQ_L^a / dQ_m^b = 0.46$ . We are therefore in the north-west region of Figure 2, where production in both industries increases. 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,  $\sigma < \sigma_b$  and  $\beta > -1$ . 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 that 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 ( $\alpha < 1, \beta = -1, a_m / a_L < 1$ ). 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 2. It has relative local sourcing of greater than unity and local firms relatively more export oriented than the project, ( $\alpha > 1, \beta = -1, a_m / a_L > 1$ ). 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 ( $\alpha < 1$ ), creating a positive production impact, in which relative local sourcing is unity, and is in the same market segment. This is the case given in row 2 of Table 1, and it is reproduced as the first row of Table 2 for reference.

**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 become Cournot-Nash competitors, recognising the impact of their behaviour on the industry aggregates, and consequently restricting output somewhat more and setting higher price cost margins. In row 3 we assume that the extent of product differentiation amongst varieties of upstream products 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 forward 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 but 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 openness 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.

**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, i.e. 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 by reducing market shares of existing firms and adding a new variety the project has a pro-competitive effect 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 (row 1) 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 production, and hence the large welfare gain of \$0.32 per \$1 production from the project.

**Summary:** 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.

## 5. Investment in an Upstream Industry

We now turn attention to the case in which the investment occurs in an upstream industry. As before the project is in industry  $b$ , but input output coefficients are now changed such that this is the upstream industry, and  $a$  is downstream. As in the previous section, we first provide an intuitive discussion of the main effects using a simple graph and then investigate the magnitude of the effects through numerical simulations of our model.

### 5.1 Initial Production- and Feedback Effects

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 start with supply and demand analysis, now looking at the upstream market, rather than the downstream.

Figure 3, like Figure 1, shows the shift in the 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  $E_1$ . This initial effect allows the number of firms in the upstream industry to change, holding the number in the downstream industry constant. Associated with this the price of upstream output has fallen, so the 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 shift of the derived demand curve to  $D_2$ , so inducing further output expansion in the upstream industry, 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 complementarity that can arise. Initial crowding out effects in the upstream industry are offset by increased downstream demand, this arising from increased profitability and entry in the downstream industry.

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 100% crowding out of local upstream production, so there is no initial production effect, 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. if relative sourcing is 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 industry 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 backward linkages.

This suggests that the basic model cannot generate any forward linkages once we allow for entry and exit in the upstream industry in the case where the project competes in the same market segment as the local firms. 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, i.e. local substitutability is less than one. In this case the project does not lead to full crowding out in the project's own industry. Hence, as long as local substitutability is less than one, the project does lead to a reduction in the price of upstream output and therefore generates a forward linkage.

The second amendment is that most actual projects create both forward and backward linkages. There are many industries, all linked through non-zero input output coefficients. Thus, the project may be 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 (rather than for export) this leads to a price reduction for the intermediate industry, generating a forward linkage.

## 5.2 Numerical Simulations

To proceed further, it is best to see how this works in some illustrative simulations on the model. As in the case of a downstream investment, we start by investigating the effects of changes in the project characteristics and then investigate the effects of changes in the industry characteristics.

**Project Characteristics:** The first row in Table 3 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, so  $\alpha = 1$ ,  $\beta = -1$ . Firms in the upstream industry do not use intermediate goods, so sourcing terms are not applicable. In the short run (for a fixed number of local suppliers) there is an increase in production in the upstream industry, this causing a 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 ( $\alpha < 1$ ,  $\beta = -1$ )? This case is given in the second row. In the short run we see a larger expansion in upstream output and smaller profit loss (local firms are not being forced to contract as much), but also 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 ( $\alpha = 1, \beta < -1$ ). 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 which increases downstream output and 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 not 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.

**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.

We next analyze what happens if the downstream industry is less competitive, by switching to Cournot-Nash competition in row 2 and increasing the degree of product differentiation in row 3. This 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, i.e. 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 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.

**Upstream Industry Characteristics:** 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.<sup>8</sup> 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.

**Summary:** The experiments above suggest the following conclusions:

1. *Project characteristics:* 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. *Downstream industry characteristics:* Gains will be larger the more open is the downstream industry to international trade and competition.
3. *Upstream industry characteristics:* Gains will be larger the more imperfectly competitive is the upstream industry.

## 6. Case Studies

To establish how the predictions from the theory compare to the experience of real world companies we performed ten case studies of EBRD financed investment projects. We relied largely on interviews with industry analysts and the project managements as well as information provided by the EBRD. For each case study Table 5 lists the industry the project company was active in and shows that our sample covered a wide variety of industries. Since the project companies agreed to participate in the case studies on the condition of confidentiality we can only provide an overview of the case studies in this paper.

The theory predicts that the extent of crowding out of local production in the project industry

---

<sup>8</sup> We do not simulate a switch to Cournot competition, since the project is now competing in a different market

and the extent of backward linkages depend crucially on three measures: i. ‘relative local supply’ defined as the additional local supply of the project divided by the local supply generated by an average local company; ii. ‘relative local sourcing’ defined as the project’s usage of local inputs per unit output divided by the usage of local inputs per unit output by an average local firm; iii. ‘local substitutability’ defined as the number of local sales by local firms displaced by one unit of local sales by the project. Estimates of relative local supply and relative local sourcing can be obtained using available information about the export orientation and the sourcing strategies of the project and its local competitors and the extent to which the project is import replacing. The third measure – local substitutability – is in general more difficult to pin down and in trying to do so we relied largely on the opinions of industry analysts and the project management. Figure 4 in the appendix summarizes the information about the three measures for each case study. Note that this figure corresponds to Figure 2 from the theory part of the paper and, in particular that the dotted lines in Figure 4 correspond to *aa* line in Figure 2. It can be seen that the projects varied widely on all three measures.

As can be seen from the figures, the local substitutability measure was quite low in all ten cases. This reflects the fact that the investments were performed in the early to mid-1990s at a time when there were only very few local companies that produced goods which could compete with the foreign- and the high quality producing local project companies. Since the project companies were active in different market segments than the local competitors, one would not expect much crowding out of local production. Indeed, in five cases we found no evidence of crowding out and in the other five crowding out was very limited. Thus in all ten cases there was a significant net increase in local production, in line with what the theory would predict.

Although all projects led to net increases in local production, they differed greatly in the extent to which they generated backward and forward linkages. Consider first the backward linkages. The theory shows that production increases in the project industry can generate backward linkages and, through this channel, lead to additional welfare gains. Other things equal, the backward linkages are increasing in the extent to which the project companies source their inputs locally. In six of the case studies high transportation costs for their inputs forced the project

---

segment.

companies to buy a significant fraction of their inputs from local suppliers. When the project company was large enough the additional demand that was generated by the investment then translated into significant additional upstream production by local suppliers.

For example, the project in Case Study 2 involved a significant quality improving and production expanding investment by a large Eastern European food manufacturer in 1992. The investment led to a significant increase in local food production both because the project company was essentially a monopolist in most of its core markets and because the investment was largely intended to increase the company's exports. The most important upstream industries for the project company were advertising, agriculture and packaging. While we found no evidence for backward linkages into advertising we did find evidence for such linkages into agricultural and packaging goods. Initially the company imported all of its packaging material since the quality of the local industry was not satisfactory. However, from the beginning the company's management had a strong interest in sourcing packaging material locally to economize on labor and transportation costs and therefore cooperated with local suppliers to improve their quality. Following the project investment, local and foreign firms invested significantly in the packaging industry, drastically increasing capacity and average quality. This enabled the company to switch to local suppliers and by 1998 it became one of the largest customers of the local packaging industry. Management and industry analysts agree that the company played a significant part in the development of the local packaging industry. They also agree that there was a feedback effect from the improvements in the local packaging industry to some of the company's competitors. In particular, suppliers that received help from the company or invested in quality upgrading in the hope of obtaining contracts with it ended up selling their improved products to other downstream firms, some of which were competitors of the company. Following the investment the company also became one of biggest customers for a number of locally produced agricultural goods. The management of one of their suppliers, the largest local sugar producer, told us that the company's demand was a key factor in their decision to make their own capacity and quality improving investments. Given that in 1998 the sugar producer was making 20% of its sales to the project company such claims certainly seem plausible. In Case Study 2, therefore, we found strong evidence that the investment led to backward linkages, just as the theory would predict.

As an example of the different type of backward linkage, consider Case Study 3. This case study focused on a large greenfield investment by a western chemical company in an Eastern European country in 1994. The factory that was built produced only one product and there were no local companies that produced any close substitutes. Not surprisingly therefore, the investment led to a net increase in local production. Since the company procured its most important input from a local supplier one would expect that the investment led to backward linkages. This was indeed the case. However, the backward linkage did not take the standard form of an increase in upstream production but instead it took the form of a reduction in upstream pollution. In particular, the locally produced input was actually a by-product of the suppliers' production of other chemical goods. Before the investment there was no local demand for this by-product and high transport costs made exports impossible. The input was therefore just a waste product that was burnt at the supplier's factory. The investment allowed the supplier to turn polluting waste product into a revenue generating input.

While we found evidence of backward linkages for six projects, we did not find any for the other four. In line with the theory this was due to the project companies sourcing most of their inputs from foreign suppliers. This in turn was due to the low transportation costs of the inputs and the scarcity of high quality producing local suppliers.

As an example of an investment in which a significant increase in the local production of the project industry did not translate into increased demand for the local upstream industry, consider Case Study 5. This case study focused on the investment by a metal processing company in an Eastern European country in 1998 that allowed the company to increase its capacity by 400%. In the case study we conclude that although there were other local companies producing similar products, crowding out of local production was limited since the investment was used almost exclusively to increase exports. In spite of the increase in local production, however, the investment did not generate any backward linkages. In fact, if anything it reduced the local demand for the company's most important input, steel. The reason is that before the investment the company was too small to import steel from neighboring countries and thus relied on locally produced steel. After the investment, however, the company's demand was large enough to allow it to procure steel from abroad and it soon switched from local steel manufacturers to foreign ones. Thus, in this case, as in



three of the others, no positive backward linkages were generated.

Consider next the forward linkages. The theory shows that production increases in the project industry can generate forward linkages and, through this channel, lead to additional welfare gains. Other things equal, the forward linkages are decreasing in the export orientation of the project. Although we found some evidence for forward linkages they were, in general, quite limited.

Given the strong export orientation of most of the project companies and our theoretical analysis above, this is not very surprising. The investments by the food manufacturer and the metal processor that we discussed above, for instance, were explicitly intended to increase exports, not local sales. As a result we could not find any evidence for increases in downstream production that could be attributed to the two investments. In contrast, we did find some evidence for forward linkages in the case of the chemical company that was discussed above. In particular, the chemical company's most important customer, accounting for about 15% of its sales, was a local manufacturing company that did not face any competition from other local firms but did face severe import competition. Following the investment the manufacturer made the chemical company its sole supplier for this particular input. Industry analysts believe that local availability of the input was an important factor in the manufacturer's ability to successfully compete with the imports.

To conclude, all the projects that we looked at were financially successful and led to net increases in the local production of the project industries. Nevertheless, there are large differences in the extent to which the projects generated backward and forward linkages and these differences are broadly in line with what the theory predicts. Together the theoretical analysis and the case studies point to the importance of looking past the immediate financial success of a project and to the linkages that it generates when assessing its welfare implications.

## **7. Conclusions**

Spillovers from investment projects and 'linkages' between these projects and the rest of the economy are a perennial concern for policy makers in developed, as well as developing and transition countries. There is some evidence of such effects, although the picture is quite mixed (see Barba Navaretti and Venables (2004) for a review of evidence). This paper sets out a theoretical framework within which linkage effects can be quantified and evaluated. The theoretical mechanism

is a combination of input-output linkages between firms, increasing returns to scale and imperfect competition, meaning that pecuniary externalities are present in the industries under study. Our findings are the identification of circumstances under which effects are likely to be present, depending on the market orientation, sourcing decisions, and demand substitutability of the project as compared to local firms. Given the presence of effects, we show that their magnitude is likely to be greater the less competitive are the industries affected and the lower the substitutability between the project and local production. Extensive simulation analysis of different cases indicates that welfare gains once these linkage effects are taken into account can – depending on characteristics of the industry and the project – be several times larger than those that would occur without linkages. This is a significant magnitude, important for practical project appraisal.

**Table 1:** Response to one unit production by project in downstream industry.  
(upstream industry  $a$ ; project in downstream, industry  $b$ )

	Short run	Initial production effect, no feedback.	Full effect, with feedback
<b>1: Base:</b> $\alpha = 1, \beta = -1,$ $a_m / a_L = 1.$	Prodn: $a$ $b$ 0.25, 0.411 Profit, c.s, welfare -0.067, 0.241, 0.174	Prodn: $a$ $b$ 0.0, 0.0 Profit, c.s, welfare 0.0, 0.0, 0.0	Prodn: $a$ $b$ 0.0, 0.0 Profit, c.s, welfare 0.0, 0.0, 0.0
<b>2: Project export oriented.</b> $\alpha < 1, \beta = -1,$ $a_m / a_L = 1.$	Prodn: $a$ $b$ 0.53 0.82 Profit, c.s, welfare 0.0699 0.0697 0.140	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.0915 0.000 0.0915	Prodn: $a$ $b$ 0.79 0.88 Profit, c.s, welfare 0.0 0.225 0.225
<b>3: Project in separate market segment:</b> $\alpha = 1, \beta > -1,$ $a_m / a_L = 1.$	Prodn: $a$ $b$ 0.29, 0.58 Profit, c.s, welfare -0.0261 0.278 0.251	Prodn: $a$ $b$ 0.12, 0.29 Profit, c.s, welfare 0.0236 0.109 0.132	Prodn: $a$ $b$ 0.20, 0.34 Profit, c.s, welfare 0.0, 0.166 0.166
<b>4: Project export oriented and low relative local srcing</b> $\alpha < 1, \beta = -1,$ $a_m / a_L < 1.$	Prodn: $a$ $b$ 0.01, 0.82 Profit, c.s, welfare -0.035 0.070 0.034	Prodn: $a$ $b$ -0.06, 0.69 Profit, c.s, welfare -0.013 0.00 -0.013	Prodn: $a$ $b$ -0.11, 0.66 Profit, c.s, welfare 0.0, -0.033 -0.033
<b>5: Project import oriented and high relative local srcing</b> $\alpha > 1, \beta = -1,$ $a_m / a_L > 1.$	Prodn: $a$ $b$ 0.49, 0.38 Profit, c.s, welfare -0.026 0.264 0.238	Prodn: $a$ $b$ 0.21, -0.055 Profit, c.s, welfare 0.043 0.00 0.043	Prodn: $a$ $b$ 0.36, 0.03 Profit, c.s, welfare 0.0, 0.103 0.103

**Table 2:** Response to unit production by export oriented project in downstream industry. (upstream industry  $a$ ; project in downstream, industry  $b$ :  $\alpha < 1$ ,  $\beta = -1$ ,  $a_m / a_L = 1$ ).

	Short run	Initial production effect, no feedback.	Full effect, with feedback
<b>1: Project export oriented.</b>	Prodn: $a$ $b$ 0.53 0.82 Profit, c.s, welfare 0.0699 0.0697 0.140	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.0915 0.000 0.0915	Prodn: $a$ $b$ 0.79 0.88 Profit, c.s, welfare 0.0 0.225 0.225
<b>2: Upstream industry less competition (Cournot-Nash)</b>	Prodn: $a$ $b$ 0.53 0.81 Profit, c.s, welfare 0.0839 0.0702 0.154	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.104 0.00 0.104	Prodn: $a$ $b$ 0.80 0.89 Profit, c.s, welfare 0.0 , 0.231 0.231
<b>3: Upstream industry less product diff. (reduce <math>\sigma^a</math>)</b>	Prodn: $a$ $b$ 0.53 0.82 Profit, c.s, welfare 0.0966 0.0697 0.166	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.114 0.000 0.114	Prodn: $a$ $b$ 0.92 0.99 Profit, c.s, welfare 0.0 , 0.347 0.347
<b>4: Upstream industry more import penetration</b>	Prodn: $a$ $b$ 0.30 0.82 Profit, c.s, welfare 0.0225 0.0697 0.0921	Prodn: $a$ $b$ 0.25 0.69 Profit, c.s, welfare 0.0508 0.000 0.0508	Prodn: $a$ $b$ 0.79 0.88 Profit, c.s, welfare 0.0 0.225 0.225
<b>5: Upstream industry more export oriented</b>	Prodn: $a$ $b$ 0.53 0.82 Profit, c.s, welfare 0.0699 0.0697 0.140	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.0915 0.00 0.0915	Prodn: $a$ $b$ 1.1 0.88 Profit, c.s, welfare 0.0 0.225 0.225
<b>6: Downstream industry less competition (Cournot-Nash)</b>	Prodn: $a$ $b$ 0.55 0.83 Profit, c.s, welfare 0.0638 0.0779 0.142	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.0918 0.00 0.0918	Prodn: $a$ $b$ 0.80 0.89 Profit, c.s, welfare 0.0 , 0.226 0.226
<b>7: Downstream industry more product diff. (reduce <math>\sigma^b, \sigma</math>)</b>	Prodn: $a$ $b$ 0.49 0.73 Profit, c.s, welfare 0.0293 0.156 0.185	Prodn: $a$ $b$ 0.34 0.49 Profit, c.s, welfare 0.0677 0.000 0.0677	Prodn: $a$ $b$ 0.60 0.64 Profit, c.s, welfare 0.0 , 0.187 0.187
<b>8: Downstream industry more import penetration.</b>	Prodn: $a$ $b$ 0.56 0.90 Profit, c.s, welfare 0.0915 0.0699 0.161	Prodn: $a$ $b$ 0.46 0.69 Profit, c.s, welfare 0.0915 0.000 0.0915	Prodn: $a$ $b$ 1.0 1.2 Profit, c.s, welfare 0.0 , 0.337 0.337
<b>9: Downstream industry more export orientation.</b>	Prodn: $a$ $b$ 0.55 0.95 Profit, c.s, welfare 0.101 0.0178 0.119	Prodn: $a$ $b$ 0.52 0.89 Profit, c.s, welfare 0.104 0.000 0.104	Prodn: $a$ $b$ 1.2 1.6 Profit, c.s, welfare 0.0 , 0.323 0.323

**Table 3:** Response to one unit production by project in upstream industry.  
(project in upstream industry  $b$ ; downstream industry  $a$ )

	Short run	Initial production effect, no feedback.	Full effect, with feedback
<b>1: Base</b> $\alpha = 1, \beta = -1.$	Prodn: $b$ $a$ 0.38 0.073 Profit, c.s, welfare -0.099 0.238 0.138	Prodn: $b$ $a$ 0.00 0.00 Profit, c.s, welfare 0.000 0.000 0.00	Prodn: $b$ $a$ 0.00 0.00 Profit, c.s, welfare 0.0 0.00 0.00
<b>2: Project more export oriented</b> $\alpha < 1, \beta = -1.$	Prodn: $b$ $a$ 0.81 0.021 Profit, c.s, welfare -0.032 0.068 0.037	Prodn: $b$ $a$ 0.69 0.00 Profit, c.s, welfare 0.000 0.000 0.00	Prodn: $b$ $a$ 0.69 0.00 Profit, c.s, welfare 0.0 0.00 0.00
<b>3: Project in separate market segment:</b> $\alpha = 1, \beta > -1,$	Prodn: $b$ $a$ 0.55 0.084 Profit, c.s, welfare -0.0630 0.274 0.211	Prodn: $b$ $a$ 0.27 0.032 Profit, c.s, welfare 0.0104 0.103 0.113	Prodn: $b$ $a$ 0.29 0.067 Profit, c.s, welfare 0.0 0.126 0.126

**Table 4:** Response to one unit production by project in upstream industry in distinct market segment. (project in upstream industry  $b$ ; downstream industry  $a$ ,  $\alpha = 1$ ,  $\beta > -1$ )

	Short run	Initial production effect, no feedback.	Full effect, with feedback
<b>1:</b>	Prodn: $b$ $a$ 0.55 0.084 Profit, c.s, welfare -0.0630 0.274 0.211	Prodn: $b$ $a$ 0.27 0.032 Profit, c.s, welfare 0.0104 0.103 0.113	Prodn: $b$ $a$ 0.29 0.067 Profit, c.s, welfare 0.0 0.126 0.126
<b>2: Downstream industry less competition</b> (Cournot-Nash)	Prodn: $b$ $a$ 0.55 0.085 Profit, c.s, welfare -0.0593 0.272 0.213	Prodn: $b$ $a$ 0.27 0.032 Profit, c.s, welfare 0.0119 0.102 0.114	Prodn: $b$ $a$ 0.29 0.069 Profit, c.s, welfare 0.0 , 0.126 0.126
<b>3: Downstream industry more product differentiation</b> (reduce $\sigma^a$ )	Prodn: $b$ $a$ 0.55 0.074 Profit, c.s, welfare -0.0592 0.274 0.215	Prodn: $b$ $a$ 0.27 0.028 Profit, c.s, welfare 0.0121 0.102 0.114	Prodn: $b$ $a$ 0.29 0.071 Profit, c.s, welfare 0.0 , 0.134 0.134
<b>4: Downstream industry more import penetration</b>	Prodn: $b$ $a$ 0.57 0.087 Profit, c.s, welfare -0.0629 0.275 0.212	Prodn: $b$ $a$ 0.29 0.034 Profit, c.s, welfare 0.0093 0.106 0.115	Prodn: $b$ $a$ 0.32 0.13 Profit, c.s, welfare 0.0 0.146 0.146
<b>5: Downstream industry more export oriented</b>	Prodn: $b$ $a$ 0.55 0.15 Profit, c.s, welfare -0.0465 0.256 0.209	Prodn: $b$ $a$ 0.27 0.058 Profit, c.s, welfare 0.0167 0.096 0.112	Prodn: $b$ $a$ 0.32 0.18 Profit, c.s, welfare 0.0 0.138 0.138
<b>6: Upstream industry less competition</b> (reduce $\sigma^b, \sigma$ )	Prodn: $b$ $a$ 0.68 0.11 Profit, c.s, welfare -0.043 0.379 0.335	Prodn: $b$ $a$ 0.44 0.063 Profit, c.s, welfare 0.0205 0.204 0.224	Prodn: $b$ $a$ 0.47 0.13 Profit, c.s, welfare 0.0 , 0.251 0.251
<b>7: Upstream industry more import penetration.</b>	Prodn: $b$ $a$ 0.76 0.072 Profit, c.s, welfare -0.0251 0.234 0.209	Prodn: $b$ $a$ 0.48 0.036 Profit, c.s, welfare 0.012 0.115 0.127	Prodn: $b$ $a$ 0.49 0.075 Profit, c.s, welfare 0.0 , 0.141 0.141
<b>8: Upstream industry more export orientation.</b>	Prodn: $b$ $a$ 0.66 0.063 Profit, c.s, welfare -0.0474 0.206 0.159	Prodn: $b$ $a$ 0.24 0.024 Profit, c.s, welfare 0.00800 0.0787 0.0867	Prodn: $b$ $a$ 0.26 0.051 Profit, c.s, welfare 0.0 , 0.0963 0.0963

**Table 5:** Case Study Industries

Case Study	Industry
CS 1	Sugar
CS 2	Food
CS 3	Chemical
CS 4	Automotive
CS 5	Metal Processing
CS 6	Packaging
CS 7	Glass
CS 8	Beer
CS 9	Fruit and Vegetable Processing
CS 10	Telecommunication

APPENDIX 1: Parameters and initial equilibrium values, base case of Table 1:

Elasticities of substitution,  $\sigma = 5$ .

Aggregate demand elasticities,  $\eta = 2$ .

Efficiency parameters,  $k = 0.8$ .

Number of local firms each industry: 4.00 4.00

Number of foreign firms each industry: 0.44 0.44

Firm level fixed costs, industry  $a = 9.25$ , industry  $b = 6.19$ .

Exogenous expenditure levels, local:  $Y = 100$ ; foreign,  $Z = 2.25$

Input output coefficient:  $a_m = a_L = 0.5$ ;

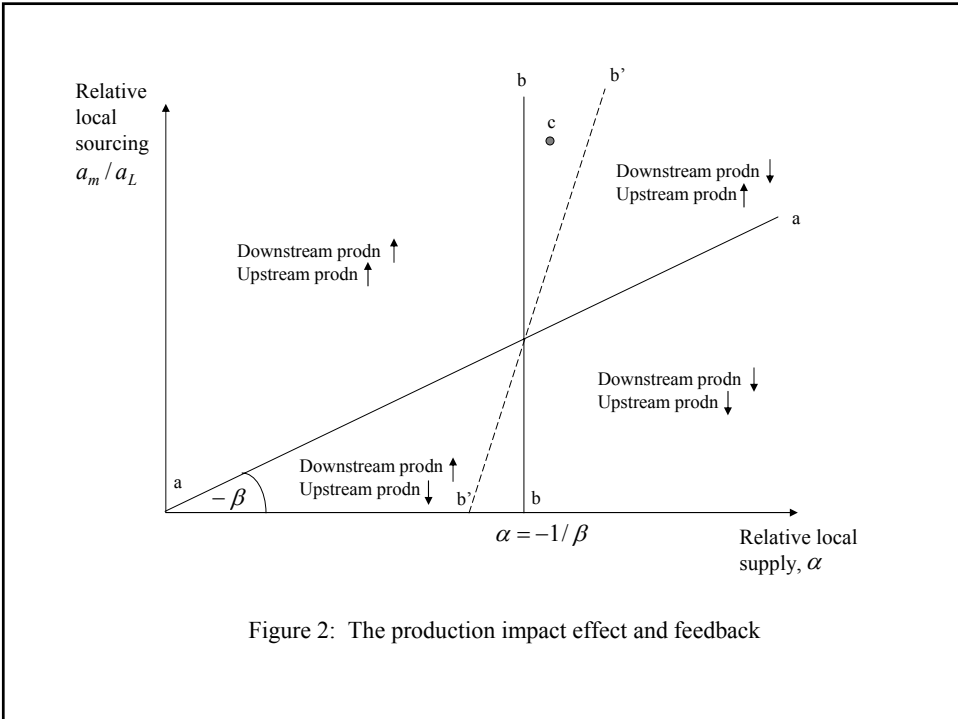
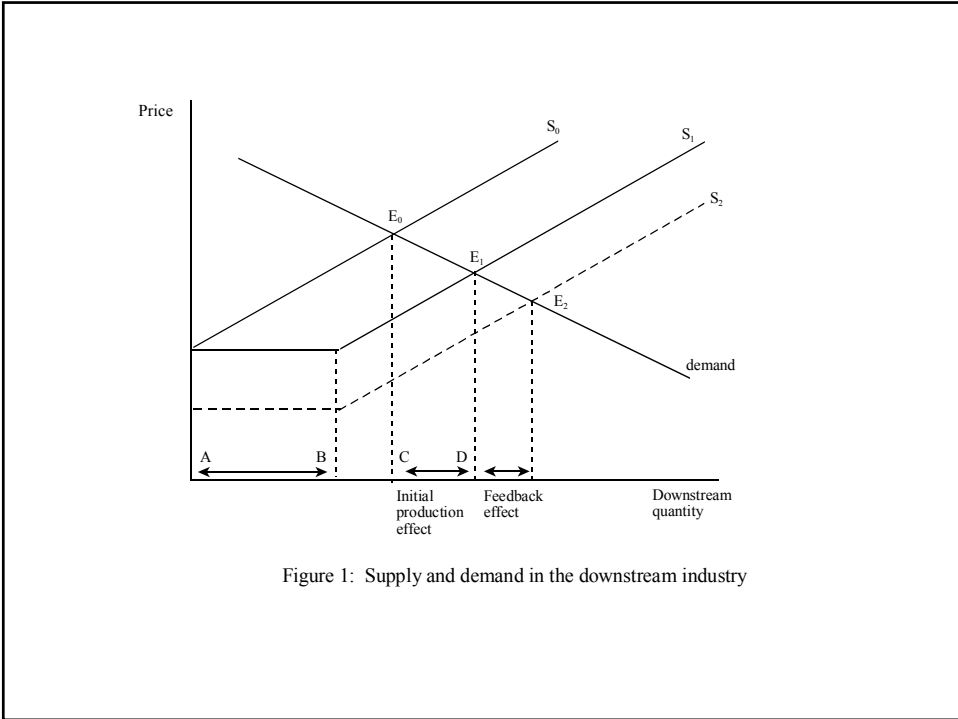
Equilibrium values of exports relative to production, all firms, 0.1.

In the benchmark case we assume that the project has no import replacement effect and all firms have the same export share, so relative local supply  $\alpha = 1$ . The project is in the same market segment as local firms, so  $\sigma = \sigma^b$  implying  $\beta = -1$  (equation (8)).



## References

- Baldwin R., R. Forslid, P. Martin, G. Ottaviano, and Frederic Robert-Nicoud (2003), *Economic Geography and Public Policy*, Princeton: Princeton University Press.
- Barba Navaretti, G. and A.J. Venables (2004) ‘*Multinational firms in the world economy*’, Princeton: Princeton University Press.
- Dixit, A. K., and J. E. Stiglitz. (1977), “Monopolistic competition and optimum product diversity” *American Economic Review*, 67 (3): 297-308.
- Fujita, M., P. Krugman and A.J. Venables (1999), *The Spatial Economy; Cities, Regions and International Trade*, MIT press.
- Little, I.M.D and J.A. Mirrlees (1968) ‘*Manual of industrial project analysis in developing countries*’ vol II, OECD, Paris.
- Markusen, J. R. and A.J. Venables (1999), “Foreign direct investment as a catalyst for industrial development”, *European Economic Review*, 43, 335-356.
- Matouschek, N. and A.J. Venables (1999), “Evaluating Investment Projects in the Presence of Sectoral Linkages – Ten Case Studies in Transition Economies,” LSE.
- Rodriguez-Clare, A. (1996), “Multinationals, linkages, and economic development,” *American Economic Review*, 86, 852-873.



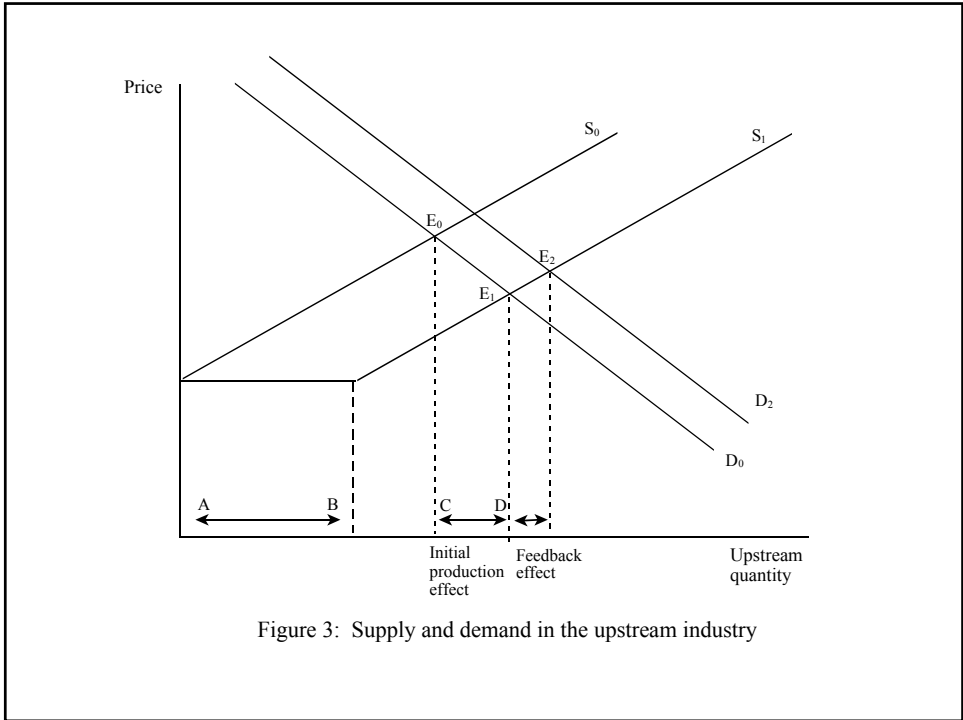


Figure 3: Supply and demand in the upstream industry

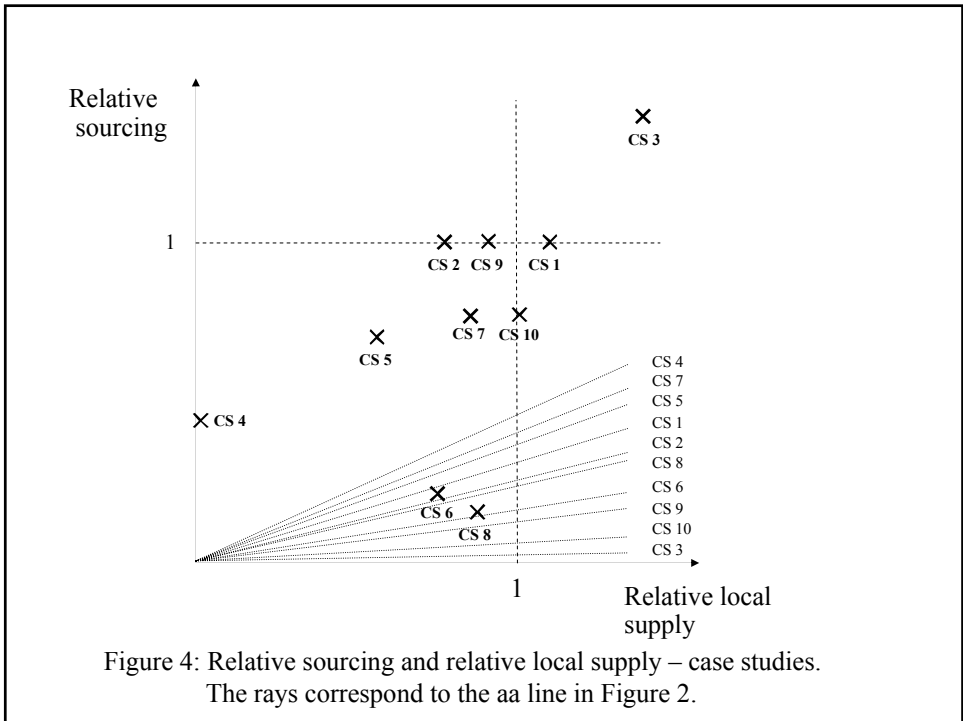


Figure 4: Relative sourcing and relative local supply – case studies. The rays correspond to the aa line in Figure 2.