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## **Trade policy and industrialisation when backward and forward linkages matter**

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### **Abstract**

This paper develops a model in which the interaction of forward and backward linkages determines the range of goods and of parts that are produced in a developing economy. Using a simple formalisation of the range and sophistication of parts used in different goods, the paper investigates the effects of trade and industrial policy. Linkages create multiplier effects so, for example, support for final goods producers can increase the range of parts produced, broadening the industrial base and attracting entry of further final goods producers. Effects depend on whether policy is targeted at appropriate margins. Policies that expand the range of parts on the margin are likely to spark more industrialisation than policies that promote parts production within the margin (parts that are already produced domestically), or parts far beyond the margin (highly sophisticated parts not used in locally produced final goods).

**Keywords:** trade policy; linkages; trade in parts; global value chain; local content restrictions.

**JEL classification:** F12, F13, 014

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## 1. INTRODUCTION

Trade and industrialisation have been deeply entwined in economic analysis since the Industrial Revolution. Classical economists from Adam Smith onwards stressed the importance that both imports and exports played in fostering industry. At least since Alexander Hamilton and Friedrich List, economists have viewed trade policy as an important lever in national development/industrialisation plans. These thinkers typically posit economic mechanisms in which the simple removal of trade barriers fails to ensure that the economy attains its first-best allocation of resources.

The study of development – or under-development as it used to be called – was extension of this early thinking. Reflecting a widespread belief that many developing nations had the intrinsic capacity to rise into the ranks of middle income or even high income nations, the search began for the set of policies that would allow poor nations to realise their potential. Since rich and industrialised were synonymous in the centuries following the Industrial Revolution, a great deal of this search has focused on the challenge of industrialisation. In particular, many influential development economists have singled out backward and forward linkages as a set of economic mechanisms that can give rise to underdevelopment (Hirschman 1969, Rostow 1960).

Analysis of linkages is also increasingly important in trade theory. When various production stages were organised within a single nation, there was little harm to conceiving of the production process as a black box in which primary factors such as labour and capital are transformed into final goods. In recent years, this seemingly harmless simplification has become increasingly less innocuous. As internationalisation of the production process proceeds, it is becoming important to open up the production function's black-box approach and track which stages go where and why (Baldwin 2006). The immediate problem confronted by a theorist working on this challenge is that of tractability.

Tractable models of backward and forward linkages in an open economy (Krugman and Venables 1995, Venables 1996) have emerged in recent decades, and been applied to trade and industrialisation (Markusen and Venables 1999, Puga and Venables 1999).<sup>1</sup> These models, in the spirit of the New Economic Geography models, work with highly symmetric goods – typically relying on Dixit-Stiglitz monopolistic competition and symmetrically differentiated products. In the simplest case, all firms produce an intermediate variety and use all other varieties, so they create forward and backward linkages (from their supply and demand respectively), and also benefit from forward and backward linkages created by other firms. Recently, theory has turned to more specific models of the unbundling and offshoring that focus on the decision to break up the production process across borders (Costinot et al. 2013, Grossman and Rossi-Hansberg 2008). These papers, however, typically eschew linkages across product-specific value chains and so the backward and forward linkages exist only in a single column of the input-output matrix. Our own work in this area shares this

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<sup>1</sup> For the wider context of trade policy and industrialisation see Harrison and Rodriguez-Clare (2010).

single-industry approach (Baldwin and Venables 2013).

The present paper posits a model that has a clear distinction between firms that produce parts and firms that use them, but which contains input-output relationships that span sectors. The model is designed to allow product-specific value chains to interact in ways that influence each other's competitiveness via backwards and forwards linkages. Several cross-product linkages are important empirically but they generally fall into two categories: those related to knowledge spillovers (R&D, learning-by-doing externalities, etc.) and those related to backward and forward linkages. In this paper, we focus on the latter. We use the model to study the impact of various trade and industrial policies, including tariffs, export and production subsidies, and local content restrictions, as well as value-chain policies.

Specifically, we look at an industry where final goods are produced using parts, with different goods using different (but overlapping) sets of parts. The range of final goods produced domestically depends positively on the range of parts produced domestically (via supply-side, or forward linkages). Simultaneously, the range of domestically produced parts depends positively upon the range of domestically produced goods (via derived-demand, i.e. backward linkages). If we call the range of parts produced the 'width' of the industrial base, and the range of final goods produced the 'height' of the industrial base, we have a model where the height of the industrial base affects and is affected by the width of the industry base.

In this setting, standard trade policy instruments have complex effects on the equilibrium level of industrialisation. For example, an across the board tariff on imported parts would normally be expected to reduce industrial competitiveness and thus reduce industrial output via the usual effective rate of protection channels. We show that, depending whether domestic parts are sufficiently good substitutes for imported parts, the parts tariff may broaden the industrial base to the point where the nation becomes competitive in a wider range of final goods. Local content restrictions and policy to attract local production of parts may have similar effects although, since different goods use different sets of parts, effects depend on industry detail and the accuracy with which such policies are targeted.

## **2. THE MODEL**

Consider a small open developing economy (Home) that can potentially produce a continuum of final goods – or 'goods' for short – using a continuum of intermediate goods – or 'parts' for short. Goods are indexed  $z$  and the set of possible goods is  $z \in [0, \infty]$ ; parts are indexed  $y \in [0, \infty]$  (where the mnemonic is that parts come before final goods as  $y$  comes before  $z$ .) Determining the equilibrium range of goods and parts that are produced at Home is the primary task of this paper.

A second, more economically advanced nation (Foreign) already makes the full range of parts and goods, and Home can import these from Foreign. Home can export goods, but we assume that Home parts, i.e. parts made in the less technologically advanced nations, are uncompetitive in Foreign. That is, the coordination costs involved in using Home parts in

Foreign-based production processes are prohibitively high. Although Home produced parts are not exported directly, they are embodied in Home final goods which are exported.

In an extension in Section 3.5, we allow Foreign firms to internalise the transaction costs by setting up parts production in Home. This reduces the coordination and transaction costs to the point where Home parts can be exported, but only via intra-firm trade. As we shall see, this opens the door to new questions concerning trade and industrialisation.

A key feature of the interaction among supply chains is that goods vary in the set of parts that they require, and parts vary in the set of goods that they supply. Central to the model, is the idea that the range of goods produced at Home depends on the range of parts produced, and vice versa. Only some parts are produced domestically, and these are parts for which demand exceeds a level which we will refer to as ‘minimum efficient scale’ (MES). As only parts for which demand exceeds their MES are produced domestically, the demand for parts that arises from one final-good sector can affect the cost conditions facing other final-good sectors. We order the parts according to their MES such that parts with higher  $y$  indices have higher MES, and we refer to these as more sophisticated parts.

### **2.1. Production technology, supply chains, and scale economies**

Each good is associated with a ‘supply chain’ in the sense that production of good  $z$  entails a good-specific set of parts  $\mathcal{Y}(z)$ . For simplicity, parts are used in fixed proportions and assembled costlessly into goods. The amount of part  $y$  used in the production of good  $z$  is  $a(y,z)$ , positive for  $y \in \mathcal{Y}(z)$  and zero otherwise. We choose units such that input coefficients for each good sum to unity,  $\int_{\mathcal{Y}(z)} a(y,z)dy = 1$  for all  $z$ .

The price of each part produced in Foreign is normalised at unity, and hence the price of each final good produced in Foreign is also unity. The price of a Foreign part in Home is  $p \geq 1$ , exceeding unity if there are trade taxes or other transaction costs. Each good that is produced in Home can source parts from Foreign (at price  $p$ ) or, if they are available, can also use domestically-produced parts. Each of these has cost  $w < 1$ . Thus, Home can produce parts more cheaply than Foreign, but a part is produced in Home only if production surpasses a part-specific minimum efficient scale (MES). Once the MES is surpassed, marginal costs for all parts are constant at  $w$ ; thus apart from the MES-related discontinuities (which create a type of external economies of scale), we work with constant returns.<sup>2</sup>

For parts that are produced at Home, domestic final-good firms will generally meet their input requirement using both domestic supply and imports. Foreign parts are imperfect substitutes for those produced at Home, perhaps for technical reasons or for reasons of security of supply. We capture this imperfect substitution between Home and Foreign parts with the cost function  $g(w,p)$ ; this says that the minimum per-unit cost of sourcing a

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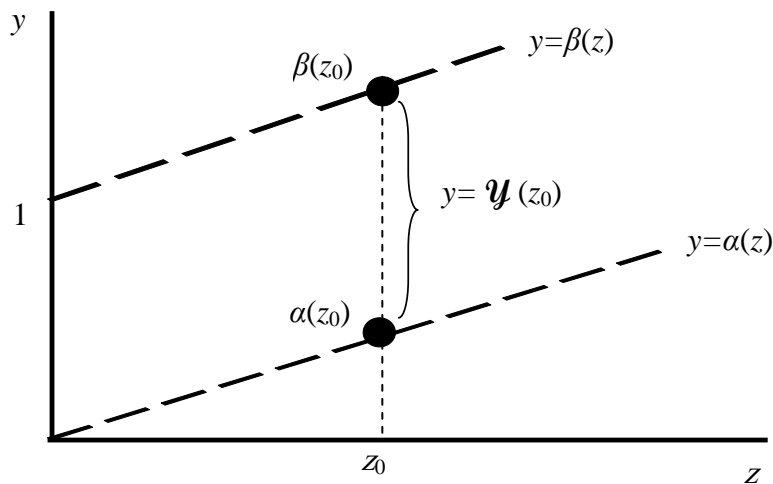
<sup>2</sup> The idea is that the marginal cost is prohibitive for production levels below the MES, and equal to  $w$  for production levels above it. For convenience,  $w$  is the same for all parts, but the MES is higher for more sophisticated parts.

particular part in Home is  $g(w,p)$  when parts are optimally sourced from domestic and foreign sources. For simplicity, this is identical for all parts and goods. This can be thought of as Home produced parts having price  $w < 1$  for parts that are produced domestically, and  $+\infty$  for parts that are not produced. Since it is technically possible to produce goods using either Home or Foreign parts alone, the elasticity of substitution of  $g(w,p)$  is greater than unity. It follows that  $p > g(w,p)$ .<sup>3</sup>

## 2.2. Continuous-range example

Calculations are simplified by assuming that each good's supply chain involves a connected set of parts, namely  $\mathcal{Y}(z) = [\alpha(z), \beta(z)]$ , where the two ends of the set signify the least and most sophisticated parts used in the production of good  $z$ . A particularly simple example of supply chains is shown in Figure 1 in which, for example, good  $z_0$  is produced with parts ranging from  $\alpha(z_0)$  to  $\beta(z_0)$ . Here the range of parts used,  $\beta(z) - \alpha(z)$ , is the same for all goods, and we set this range at unity. We order goods such that  $\alpha(z), \beta(z)$  are increasing in  $z$  and, since goods with high indices use more sophisticated parts (see Figure 1), we can also speak of high-index  $z$ 's as being more sophisticated.

**Figure 1: Simple example of product-specific supply chains.**



In the equilibrium that we study it turns out that all parts and goods from  $y, z = 0$  up to equilibrium values  $y^*$  and  $z^*$  are produced at Home. Solving the model involves finding the pair of numbers  $y^*$  and  $z^*$ . We refer to the range of parts produced at Home,  $[0, y^*]$ , as the width of the industrial base, and the range of goods produced at Home,  $[0, z^*]$ , as the height of the industrial base. These are determined simultaneously in equilibrium, but intuition is served by separating the impact of parts-production on goods competitiveness and goods

<sup>3</sup> For example with CES form,  $g(w, p) = [\omega w^{1-\sigma} + (1-\omega)p^{1-\sigma}]^{1/(1-\sigma)}$  where  $\omega \in [0, 1]$  is a share parameter and  $\sigma > 1$ . Thus, if local supply is not available  $w \rightarrow \infty$  and  $g(w, p) \rightarrow p(1-\omega)^{1/(1-\sigma)} > p$ .

production on the range of parts produced in Home.

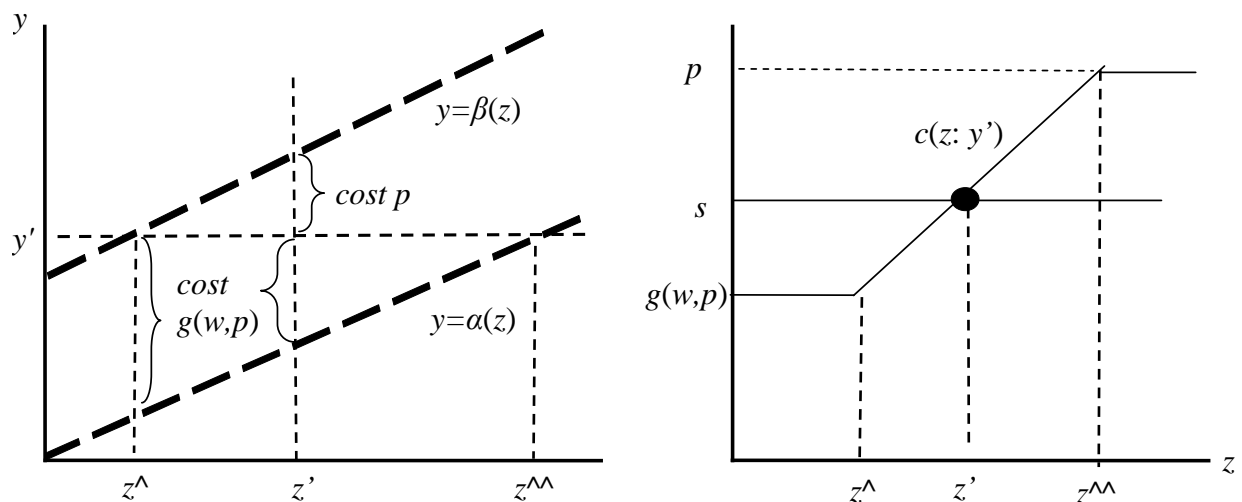
**Supply linkages: Competitiveness of domestic goods**

We look first at the decision to produce goods at Home, given the range of Home produced parts. Suppose for the moment that parts up to  $y'$  are produced domestically, so the width of the industrial base is  $[0, y']$ . The decision to produce a particular good in Home depends on costs, where the unit cost of producing good  $z$  domestically, conditional on Home industrial base  $[0, y']$ , is:

$$c(z : y') = \int_{\alpha(z)}^{y^+(z)} g(w, p)a(y, z)dy + \int_{y^+(z)}^{\beta(z)} pa(y, z)dy.$$

The first term on the right hand side gives costs incurred on parts which are produced in Home, and the second the costs of parts which have to be imported. Both terms are positive providing  $y' \in [\alpha(z), \beta(z)]$  in which case  $y^+(z) = y'$ . This is illustrated on the left panel of Figure 2; for good  $z'$  parts in the range  $y \in [y', \beta(z')]$  are imported at cost  $p$ , while parts  $y \in [\alpha(z'), y']$  are domestically available giving input cost  $g(w, p)$ .<sup>4</sup> For less sophisticated goods,  $z < z^\wedge$ , all parts used are produced in Home giving cost of production  $g(w, p)$ . Very sophisticated goods,  $z > z^\wedge$  use parts none of which are produced domestically so have cost  $p$ .

**Figure 2: Supply linkages and height of the industrial base.**



The right hand panel of the figure traces out the cost function for different goods,  $c(z : y')$ ,

<sup>4</sup> Recall that when a part is domestically available a goods producer will draw on both domestic and import sources, so the unit cost of the part is  $g(w, p)$ .

that corresponds to this. It is horizontal at  $g(w, p)$  for goods,  $z < z^\wedge$ , and horizontal at  $p$  for goods  $z > z^\wedge$ . Between these values it is increasing in  $z$  because more sophisticated goods require a higher share of imported parts and, as we saw in the previous sub-section,  $p > g(w, p)$ .

A particular good will be produced at Home if its costs, inclusive of any taxes or subsidies, are less than the world price of the good, which is unity.<sup>5</sup> Home may provide a per-unit production subsidy at rate  $s - 1$ , meaning that per unit receipts from exporting are equal to  $s$ . For any given  $y'$ , Home production of good  $z$  is therefore competitive if  $c(z': y') \leq s$ , i.e. costs are less than the world price plus subsidy. Hence, the threshold value for the good  $z'$  that just breaks even is  $z$  that solves:

$$s = \int_{\alpha(z)}^{y^+(z)} g(w, p)a(y, z)dy + \int_{y^+(z)}^{\beta(z)} pa(y, z)dy . \quad (1)$$

We summarise this relationship as  $z' = Z(y')$ .

The threshold value,  $z'$ , is illustrated by the intersection on right panel of figure 2, and we assume that this is on the upwards sloping segment of the cost curve, i.e. that  $p > s > g(w, p)$ . For  $z$  below this threshold good the fraction of inputs sourced domestically is higher and, since  $p > g(w, p)$ , costs are less than  $s$ ; it is profitable to produce all such goods in Home.

For analytical clarity in much of what follows we simplify exposition by making strong assumptions about technology. These are that  $\alpha(z) = z$  and  $\beta(z) = 1 + z$ , and that all parts are used with equal intensity so  $a(y, z) = 1$  for all  $y \in [\alpha(z), \beta(z)]$ . Costs then take the form  $c(z: y') = (y' - z)g(w, p) + (z + 1 - y')p$ .<sup>6</sup> Setting this equal to  $s$  and rearranging, the relationship  $z' = Z(y')$  is:

$$\text{Supply linkage, } Z(y): \quad z = y - \frac{p - s}{p - g(w, p)} . \quad (1')$$

This is illustrated in Figure 4 below and we discuss it further after looking at the other relationship in the model, the demand linkage. However, we note that both the numerator and denominator of the final expression in (1') are positive, and that  $p > s > g(w, p)$  (see the right hand panel of figure 2). It follows that the right hand side of (1') is decreasing in  $p$ .<sup>7</sup>

<sup>5</sup> The world price is 1 since Foreign produced goods use measure 1 of foreign parts, each of which is produced abroad at cost 1.

<sup>6</sup> For  $z \in [z^\wedge, z^\wedge]$ . For  $z < z^\wedge$ ,  $y^+(z) = \beta(z) = 1 + z$  so  $c(z: y') = g(w, p)$ . For  $z > z^\wedge$ ,  $y^+(z) = \alpha(z) = z$  so  $c(z: y') = p$ , as on figure 2.

<sup>7</sup> Differentiating (1'),  $dz/dp = -[s - g + (p - s)g_p]/(p - g)^2 < 0$ .

**Demand linkages: MES and demand for local parts**

Turning to the demand linkages, we now look at the entry of Home parts producers, taking as given (for the moment) the range of domestically produced goods,  $[0, z'']$ .

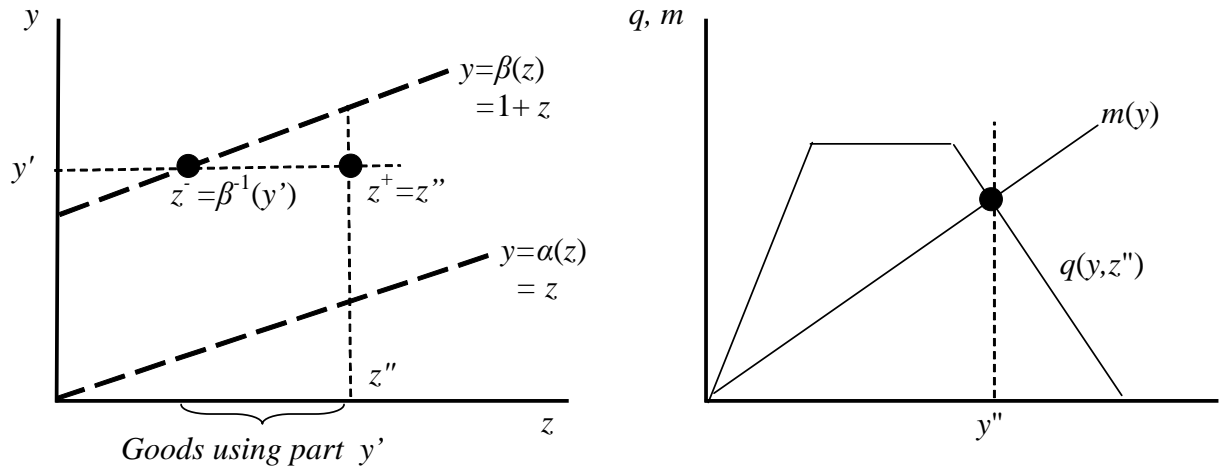
Home production of a particular part takes place if demand exceeds MES. Calculation of the derived demand requires information on the scale of each good that is produced at Home. There are many ways to model such demand – the simplest being that it is inelastic. We embrace this assumption. Specifically, demand for each good produced is  $\chi(z)$  (mnemonic of global demand); we treat this as a parameter and do not allow it to vary endogenously with, e.g. price.

The demand for domestically produced parts is therefore

$$q(y : z'') = \int_{z^-(y)}^{z^+(y)} g_w(w, p) a(y, z) \chi(z) dz$$

where  $g_w(w, p)$  is the partial derivative of  $g(w, p)$  with respect to the price of a local part (and thus equal to the per unit demand for local parts), and  $z^+(y)$ ,  $z^-(y)$  are the highest and lowest  $z$ 's that demand part  $y$ . Formally,  $z^+(y) = \min[z'', \alpha^{-1}(y)]$ ,  $z^-(y) = \max[0, \beta^{-1}(y)]$ . This is illustrated on the left panel of Figure 3; for example, part  $y'$  is used by goods in the interval between  $z^+(y) = z''$  and  $z^-(y) = \beta^{-1}(y)$ .

**Figure 3: Demand linkages and width of the industrial base.**



A simple expression for parts demand can be derived if, as before, we assume that  $\alpha(z) = z$ ,  $\beta(z) = 1 + z$ ,  $a(y, z) = 1$  and also that  $\chi(z) = \gamma$ , the same for all  $z$ . Demand  $q(y, z'')$  then takes the piece-wise linear inverse-U shaped form illustrated on the right-panel of figure 3.<sup>8</sup> The

<sup>8</sup> If  $\gamma$  varies with  $z$  then  $q(y, z'')$  would still be increasing, flat, then decreasing as the set of goods

intuition can be seen by increasing  $y$  from zero on the left-panel and looking at the range of final goods,  $z$ , that use Home produced part  $y$ . The downward sloping section corresponds to  $y$  such as  $y'$  in which case,  $z^-(y) = \beta^{-1}(y) = y - 1$  and  $q(y, z'') = [z'' - (y - 1)]g_w(w, p)\gamma$ .

Parts whose derived demand equals or exceeds their MES are produced domestically. We assume that more sophisticated parts have higher MES and denote this relationship by  $m(y)$ , strictly increasing. The threshold part to enter,  $y''$ , is that for which demand equals MES, i.e. is implicitly defined by the solution to  $m(y'') = q(y'': z'')$ , Thus, the threshold part is the  $y''$  that solves:

$$m(y'') = \int_{z^-(y'')}^{z^+(y'')} g_w(w, p) a(y, z) \gamma(z) dz \quad (2)$$

We summarise this relationship with function  $Y(z)$ , so:  $y'' = Y(z'')$ .

This relationship and the threshold part are illustrated in the right-panel of Figure 3, with MES assumed to be proportional to  $y$ , so  $m(y) = \mu y$ . The intersection of the curves gives the range of parts produced and, with our simplifying assumptions, this is the value of  $y$  solving  $\mu y = [z'' - (y - 1)]g_w(w, p)\gamma$ . Rearranging,

$$\text{Demand linkage } Y(z): \quad y = \frac{\gamma g_w(w, p)}{\mu + \gamma g_w(w, p)} (1 + z). \quad (2')$$

### ***Equilibrium industrialisation***

These two relationships – (1) which describes the supply-side linkages (forward linkages), and (2) which describes the demand-side linkages (backward linkages) – are the core of the model. We have stated them in general terms but to illustrate the essential interactions with a minimum of parameters we focus on (1') and (2'), employing our strong simplifying assumptions on technology and demand. These two relationships are shown on figure 4, and the equilibrium  $\{y^*, z^*\}$  is their intersection. Solving (1') and (2'):

$$y^* = \frac{\gamma g_w(w, p)}{\mu} \left( \frac{s - g(w, p)}{p - g(w, p)} \right), \quad z^* = \frac{(s - g(w, p))\gamma g_w(w, p) - (p - s)\mu}{(p - g(w, p))\mu}. \quad (3)$$

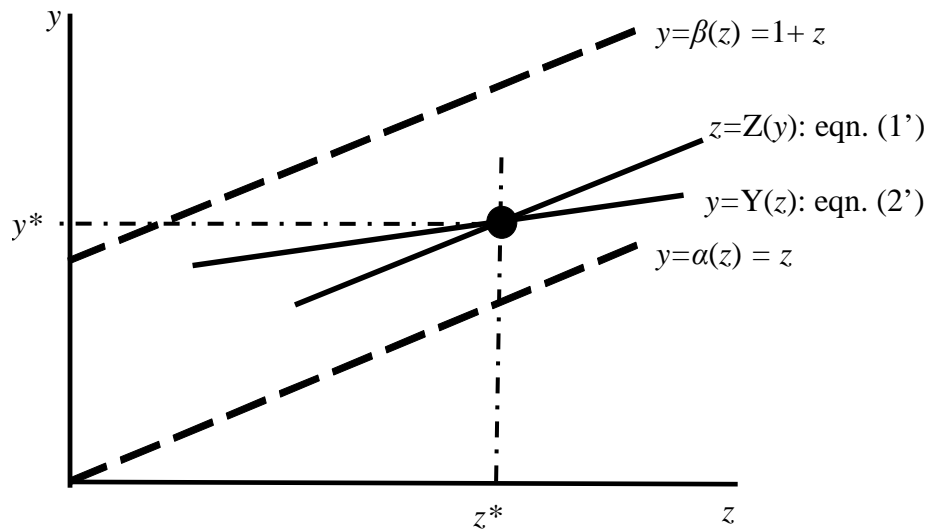
Most of the following analysis is undertaken by shifting the relationships on Figure 4. A key point for this comparative static analysis is the relative slopes of the two curves. As is clear from equation (1'), the gradient of  $Z(y)$  is unity. For  $Y(z)$ , the slope is

$$\frac{dy}{dz} = \frac{\gamma g_w(w, p)}{\mu + \gamma g_w(w, p)} < 1, \text{ giving the direction of intersection illustrated.}$$

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using part  $y$  increased, stayed constant, then fell. However, the increasing and decreasing segments would not be linear.

**Figure 4: Equilibrium industrialisation.**



### 3. POLICIES

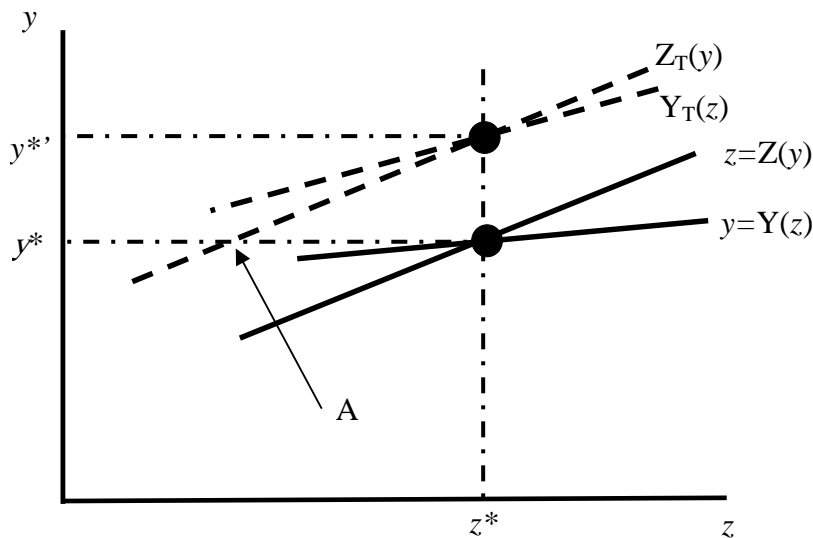
#### 3.1 Tariffs on parts

We open the policy analysis by studying the impact of tariffs on imported parts. Standard effective-rate-of-protection reasoning suggests that raising tariffs on parts lowers the protection afforded to final goods and thus should result in a reduction in final good output. As we shall show, this standard result may or may not hold in our model. Before turning to the formal analysis, we build intuition using step by step reasoning.

Consider the impact of a higher tariff on parts – which shows up as a higher  $p$  in our model – but assume for the moment that the range of parts produced,  $[0, y^*]$ , is unaffected. By inspection of (1') the  $Z(y)$  line shifts inwards when  $p$  rises (and see footnote 7). This is shown in Figure 5 as the new dashed curve  $Z_T(y)$ . If  $y$  remains at  $y^*$ , the range of final goods produced would unambiguously fall (to point A), as would be expected from an increase in the cost of imported parts. But  $y^*$  does not stay constant.

By inspection of (2') a rise in  $p$  will affect both the intercept and slope of  $Y(z)$  via its impact on  $g_w(w, p)$ . In particular, Home and Foreign parts are substitutes so the cross partial  $g_{wp}(w, p)$  is positive. In other words the per-unit demand for each Home part rises with  $p$ , so the  $Y(z)$  curve shifts up and gets steeper as shown in the Figure by  $Y_T(z)$ . The size of  $Y(z)$ 's vertical displacement depends solely on the magnitude of the cross-partial, and is greater the elasticity of substitution between Home and Foreign parts.

**Figure 5: Higher tariff on parts.**



There is a critical value of this elasticity of substitution at which the vertical displacement of  $Y(z)$  and  $Z(y)$  will be identical and there will be no change in the output of final goods. If the elasticity of substitution is higher than this, we will get what might be called a ‘Metzler Paradox’ for effective rates of protection. An increase in the effective rate of protection as traditionally measured can increase output of the final good sector rather than decrease it as might be expected.

The source of this paradox is the interplay of backward and forward linkages. While the higher parts’ tariff raise the price of imports, the shifting of expenditure from imported parts to Home parts stimulates derived demand. This in turn expands the range of parts produced at Home and thus lowers the cost of Home final goods production. Or to put it differently, the tariffs makes parts more expensive on the ‘intensive’ margin, but this may be more than offset by an extensive margin adjustment. Plainly the critical issue is here is the size of the derived demand which itself depends upon the elasticity of substitution between home and foreign parts.

More formally, we differentiate expression (3) for  $z^*$  with respect to  $p$ , deriving its effect on the equilibrium range of goods produced,

$$\frac{dz^*}{dp} = \frac{1}{(p-g)\mu} \left[ \frac{\gamma g_w g_p}{g} \{ (s-g)\sigma - g \} \right]. \quad (4)$$

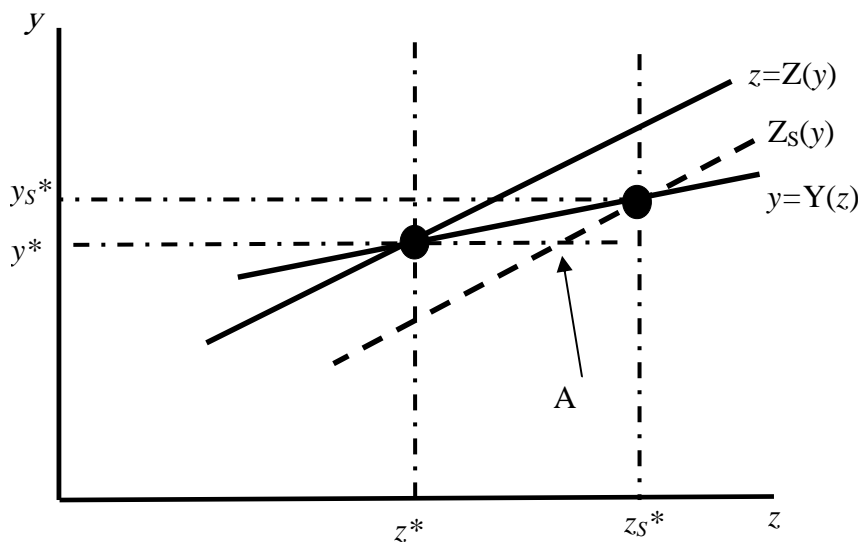
Where  $\sigma = gg_{wp} / g_w g_p$  is the elasticity of substitution. If this is small, (recall, it cannot be less than unity) then the tariff on parts shrinks the range of goods produced,  $dz^*/dp < 0$ . But if it is large enough, then  $dz^*/dp > 0$ . Sufficient demand is switched from imported to domestic parts to expand the range of parts produced by a large enough amount to cause entry of goods.

### 3.2 Subsidy for exported goods

The impact of a production subsidy is simpler. Inspection of (1') and (2') reveals that a rise in the subsidy,  $s$ , does not affect the  $Y(z)$  curve, and shifts the  $Z(y)$  curve outwards, to  $Z_S(y)$  as illustrated on Figure 6. The new equilibrium industrial structure involves an industrial base that is both higher and wider, i.e. both  $y^*$  and  $z^*$  rise.

Note that the extra derived demand from the increased  $z$  production creates something of a multiplier effect for the subsidy. The horizontal shift of  $Z(y)$  would have raised  $z^*$  to only point A, if  $y^*$  were held constant. However  $y^*$  is not constant since the higher demand for parts results in more parts crossing their MES. The presence of these new Home-produced parts boosts final good competitiveness above and beyond the direct impact of the subsidy, so  $z^*$  rises to  $z_S^*$  rather than merely point A. Again, the key innovation here is that we allow for policies to affect the extensive margin of parts production (via backward linkages) and this to affect competitiveness of goods (via forward linkages).

**Figure 6: Goods export subsidy.**



### 3.3 Subsidy on parts

There are several possible instruments for directly supporting local parts production. One is to reduce costs by a subsidy that reduces  $w$ . This has two effects. One is that it reduces the cost of Home goods production, expanding the range of goods produced:  $Z(y)$  shifts to the right since  $g_w(w, p) > 0$  in (1'). The other is that existing Home goods substitute towards use of Home produced parts, raising demand and thereby shifting more parts over their MES:

$Y(z)$  shifts up since  $g_{ww}(w, p) > 0$  in (2'). Both these shifts have the effect of causing an increase in the height and width of the industrial base.

An alternative policy might be to lower the scale at which parts firms attain MES (e.g. by reducing parts' producers sunk costs). This can be represented by a downwards shift in  $m(y)$  or, in our special case, a reduction in  $\mu$ . This expands the industrial base (shifting  $Y(z)$  to the right in (2')), also causing an increase in equilibrium  $z^*$  and  $y^*$ .

### **3.4 Local content restrictions**

A common industrialisation strategy during much of the post-WWII period involved attracting assembly activities in, say, automobiles in the hope that the local derived demand would induce development of parts production (see Baldwin 2014 for a comparison of such strategies in Thailand, Malaysia and Korea). When the subsequent industrialisation failed to appear spontaneously, governments often raised tariffs on some parts in an effort to encourage local production. As noted in the previous section, this sort of tariff policy may or may not result in further industrialisation. Another policy tool that has been used is local content restrictions which directly mandate the use of local parts as a condition for operating in the country.

To analyse an across-the-board local content restriction (LCR) consider the cost function  $g(w, p)$  which gives costs when Home and Foreign parts are mixed optimally. An LCR does not change the prices,  $w, p$ , but is a quantity measure that distorts the input mix away from its optimal level, as given by partial derivatives  $g_w(w, p), g_p(w, p)$ . A small LCR in the neighbourhood of the cost minimising input mix increases the input coefficient for Home produced parts,  $g_w$ , and reduces the coefficient for imports,  $g_p$ , but has no effect on costs,  $g(w, p)$ . This is because, by the envelope theorem, small quantity changes in the neighbourhood of the optimum are of zero value to the objective. The effect is therefore simply to shift  $Y(z)$  upwards. The consequence is an increase in the range of parts produced in Home, this inducing an increase in  $z$ , the range of goods produced.

This suggests that an LCR is an effective instrument, but two qualifying remarks need to be made. First, as an LCR gets larger, so it does start to raise costs. This increase in  $g(w, p)$  discourages entry of new goods and pushes  $Z(y)$  inwards. The analysis is then similar to that of an import tariff, with ambiguous effect on equilibrium  $z^*$ .

Second, the analysis was for an across-the-board LCR, raising the input of all locally produced parts. Effects differ if it is selective. From the policy perspective, the ideal LCR targets the marginal parts, increasing demand for those just on the verge of entry. Identifying such parts in practise is, of course, difficult. Alternatively, the policy maker may set the LCR as an aggregate, i.e. a share of local parts in the overall production of goods. In this case it seems likely that goods producers would meet the restriction by increasing inputs from

existing Home parts producers, i.e. the impact would be entirely intra-marginal. The effect is then just an inwards shift of  $Z(y)$ , with marginal  $y$  unaffected. Equilibrium  $z^*$  then falls, with  $y^*$  remaining at its initial level. The LCR has a counter-productive effect, raising costs but not targeting marginal parts.

### ***3.5 Global value chain policy analysis***

Up to this point we have assumed that Home-made parts are used only in Home production of goods, not exported directly. This is because some of these parts may be intrinsically non-tradable, and for others coordination costs of international trade are too high. One critical aspect of recent globalisation has been a reduction in these coordination costs as firms become able to organise production chains within firms but across borders, thus allowing developing nations to join the value chains of firms from advanced-technology nations.

In terms of the modelling, the big change is that now Home can export parts as well as final goods. This will enable Home parts production to reach MES on the basis of exports, not just demand from Home goods production. However, the change is not across the board. The reduction in coordination costs that allows the exportability of parts is predicated on the parts-production being undertaken by a Foreign firm inside Home. This ‘second unbundling’ does not mean that all Home parts now fit seamlessly into all Foreign production process. Only those parts whose production was overseen by the Foreign firm that will use the parts are exportable.

The thrust of all this is that the choice of which parts get exported is far more directed. A Foreign firm will set up in Home to produce certain parts.<sup>9</sup> This choice can be influenced by all manner of Home policy ranging from fairly general policies such as intellectual property protection and assurances on repatriated profits to very specific policies such as firm-specific and part-specific licensing and tax holidays. Here we look at the question of which types of GVCs should be encouraged. More specifically, GVC participation will enable Home parts to be exported, but which segment of the parts continuum should be targeted?

Formally, we model this as government directly choosing a set of Home parts that they will allow the Foreign firm to export. For simplicity we consider continuous ranges of parts of a given width, which we refer to as  $\Gamma$  (a mnemonic for GVC segment). To be concrete, we consider three discrete options:  $\Gamma_1$ ,  $\Gamma_2$ , or  $\Gamma_3$  (see Figure 7). Clearly production in all three ranges directly generates industrial employment which – assuming the usual developing nation distortions that favour overemployment in rural activities – could be considered a plus to policy makers. However, the key issue is, what are the full equilibrium effects of these interventions as backwards and forwards linkages come into play? The options differ substantially in the backward and forward linkages they trigger.

Segments  $\Gamma_1$  involves parts where Home has already overcome the MES constraint, so no

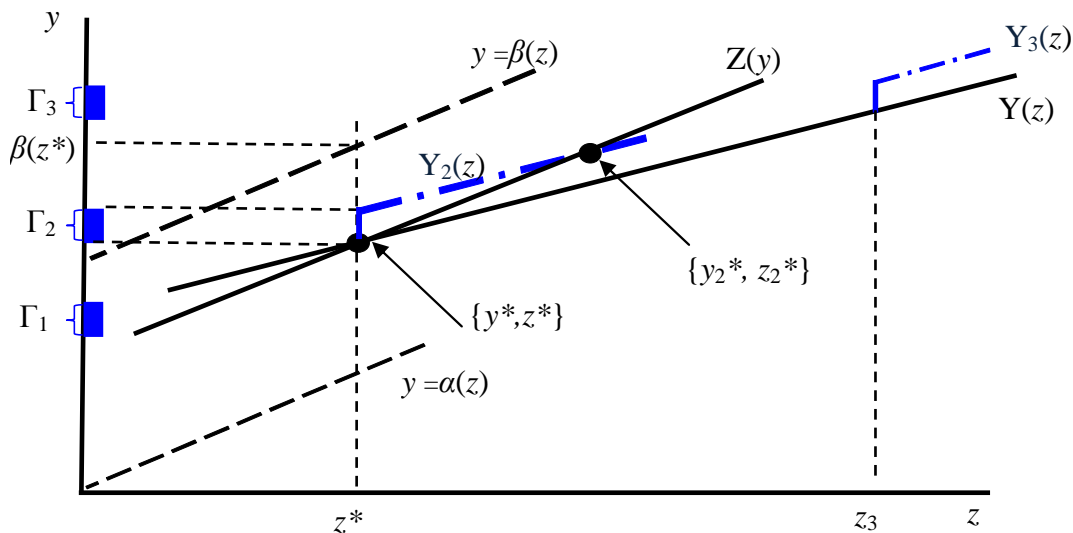
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<sup>9</sup> Parts production will be at scale greater than MES.

forward linkages are generated. In terms of the diagram, there is no shift in the  $Y(z)$  curve. As a consequence, GVC participation of this type sparks no multiplier effect on Home industry.

Segment  $\Gamma_3$  does expand the range of parts that are locally available and this does potentially create forward linkages. That is to say, it is conceivable that local production of the new range of parts would boost the competitiveness of Home  $z$  firms sufficiently to expand Home range of exported goods. The problem with  $\Gamma_3$ , however, is that the new parts are more sophisticated than those demanded by Home industries in the  $[0, z^*]$  range. It boosts the competitiveness of only very sophisticated  $z$  goods – those from  $z_3$  onwards (as shown in Figure 7) – but Home goods producers are not close to being competitive in these goods given the existing width of the industrial base. The extra competitiveness boost is not sufficient to increase  $z^*$ .

**Figure 7: Which GVC to should be joined?**



The final segment,  $\Gamma_2$ , clearly triggers both backward and forward spillovers. The extra parts directly expand the width of Home's industrial base from  $y^*$  to  $y^* + \Gamma_2$ . This shows up as an upward shift in  $Y(z)$  at  $z^*$ . Since goods slightly more sophisticated than  $z^*$  were almost competitive before the GVC came in, the boost makes them competitive, so they start production. The extra Home production of goods in turn boosts derived demand for the marginal parts so parts beyond  $y^* + \Gamma_2$  now find that demand is sufficient to overcome the MES challenge. In the end, the industrial impact of the GVC entry rises both on the  $z$  and  $y$  margins. The new equilibrium width and depth of the industrial base is at point  $\{y_2^*, z_2^*\}$ .

#### 4. CONCLUDING REMARKS

The paper presents an analytic framework that helps us think through the impact of trade

policy on industrialisation when backward and forward linkages are pervasive. The framework captures several salient features of modern trade and development. One is that the second unbundling has enabled production of parts and of final goods to be separated across space; this enables developing countries to specialise in parts of the value chain, not necessarily producing all stages of a final product. A second is that developing countries have to acquire capabilities to produce for global markets; there are many aspects to this, summarised in our model as the need to attain scale before the production of a part is viable. A third is heterogeneity: different goods require different parts and different parts are used in different goods.

Pulling these elements together creates a rich structure of possible linkages, with entry of goods (or parts) stimulating entry of other parts (or goods), this creating multiplier or amplification effects. Our model has stripped this down to essentials in order to illustrate possibilities. In our framework import tariffs on parts, export subsidies to final goods, local content requirements and promotion of inwards investment in parts production *can* all have positive multiplier effects. However, they may fail to target appropriate margins, raising costs for some firms, and costing public funds. Full welfare analysis of these policies is a topic for future research.

Policy conclusions from a model as simple as ours must inevitably be taken with a grain of salt. One implication of our line of thinking helps explain the inconsistency of outcome when similar policies are pursued by different nations. For example, developing nations around the world have unilaterally lowered tariff on imported parts. For some nations this was associated with rapid industrialisation and increased integration into global value chains. But for many, this policy has been accompanied by the opposite outcome (Rodrik 2015). In our framework, the key determinant of the outcome is the substitutability of Home and imported parts. Nations that are sufficient advanced may have more substitutable parts and thus the policy may spark industrialisation even though the opposite happens for less advanced nations.

A second line of policy implications concerns the sorts of global value chains the nation should join, or the range of local parts production that should be encouraged with local content restrictions. It is critical to consider the backward and forward linkages that such policies would endanger. The general result is that policies that expand the range of parts on the margin are likely to spark more industrialisation than policies that promote parts production within the margin (already produced parts), or parts far beyond the margin (highly sophisticated parts that are used in no locally produced final goods).

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