

## International and Development Economics

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production structures

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**Abstract**

This paper presents a simple model that is able to account for three stylised facts about international trade. First, splicing of value-adding promotes trade in the abundant factor of an economy. Second, trade in intermediate inputs rises as costs of such trade fall but that free trade is not sufficient to eradicate unemployment of the abundant factor. Third, productivity growth is lower in labour-abundant economies than in the capital-abundant economies.

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## **Trade and endogenous production structures**

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### *Abstract*

This paper presents a simple model that is able to account for three stylised facts about international trade. First, splicing of value-adding promotes trade in the abundant factor of an economy. Second, trade in intermediate inputs rises as costs of such trade fall but that free trade is not sufficient to eradicate unemployment of the abundant factor. Third, productivity growth is lower in labour-abundant economies than in the capital-abundant economies.

## **Introduction**

The past decade has witnessed unprecedented growth in international trade, and particularly within broad industries. Within the apparel and electronics industries, there has been a polarisation of labour-intensive industries towards developing countries and (human) capital-intensive design activities to industrial countries. Hanson (1996), for example, notes that skill-intensive design activities within the global apparel industry have concentrated in New York, Los Angeles, and Hong Kong while assembly activities requiring minimal skills are mostly undertaken by firms located in low-wage developing countries. Time series evidence suggests that this trend is likely to continue over time.

Some of the other stylised facts about recent trends in international trade include: increasing trade in intermediate products (Krugman, ); low rates of growth of total factor productivity amongst countries that have taken on the labour-intensive portions of the value-adding chain (Young, 1992); and rising employment and GDP growth in economies opening up to international trade (World bank, 1987). There is little doubt that falling costs of transportation and communications, together with relaxation of regulatory barriers including lowering of border taxes, have been responsible for the observed increase in international trade. Falls in communications costs that in turn lower coordination costs have given a boost to trade in intermediate inputs, thus fostering the manufacture of sub-components in different locations before final assembly of the single final consumer product. Further improvements in transportation and communications technology will permit an even greater fragmentation of the production process.

This paper builds a simple model for trade in intermediate inputs that mimics three observed realities: first, trade in intermediate inputs is a conduit for raising employment in an economy; second, the fragmentation of the value-adding chain between locations for a final consumer good is determined by the costs of trade inclusive of coordination costs; third, the rate of productivity growth in a labour-intensive economy is lower than in a capital-intensive economy due to measurement error and the nature of production technology.

### **The model**

We consider a ‘stripped-down’ production technology where a final consumer good,  $Y$ , is produced from two intermediate inputs  $A$  and  $B$  using capital ( $K$ ) and labour ( $L$ ) with a constant returns to scale (CRS) Leontief technology.

$$(1) \quad Y = aK + bL, 0 < a, b,$$

where the two components of  $Y$  can be manufactured separately as:

$$(2) \quad A = aK, \text{ and}$$

$$(3) \quad B = bL.$$

The demand for intermediate inputs  $A$  and  $B$  is derived from the demand for the final consumer good  $Y$ . The Leontief technology implies that unless the inputs are available in the required proportions as given in equation (1), their demands are zero. These are simplifying assumptions but not totally unrealistic in the context of design and assembly activities for apparel and electronics industries. In autarchy, the production of  $Y$  by any country  $j$  is given by

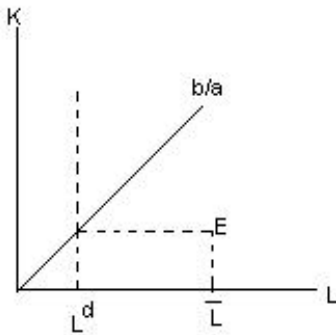
$$(4) \quad Y_A^j = \min(a\bar{K}_j, b\bar{L}_j),$$

where  $\bar{K}$  and  $\bar{L}$  are the country's endowments of capital and labour and global production of  $Y$  in the absence of trade in intermediate inputs is given by

$$(5) \quad Y_A^W = \sum_j \min(a\bar{K}_j, b\bar{L}_j).$$

The production technology in equation (5) implies that except in the very special case where  $a\bar{K}=b\bar{L}$ , one factor in every economy is always under-employed. This is shown in figure 1 below where  $(\bar{L} - L^d)$  is unemployed labour.

**Figure 1:** Under-employed labour under autarchy



Assume some fixed cost of trade in intermediate inputs of  $T$  for a home ( $H$ ) and foreign ( $F$ ) country, both of whom are small so as not to impact on the world prices of any of the commodities being traded. One could assume that either the cost of trade in  $Y$  is prohibitive as is the case for buildings or that  $T$  is the costs of trade in intermediate inputs that is over and above that for trade in the final product. This could reflect costs of coordination in the trade of intermediate inputs that have a market only when combined to form the final good. We disallow trade in any of the factors of production between  $H$

and  $F$ . Given uniform technology, trade is driven by differences in endowments of  $H$  and  $F$  only.

Now, a country has the option of exporting its under-employed factor via trade in intermediate inputs. This happens so long as there is a (derived) demand for the intermediate input and provided the cost of such trade is not prohibitive. With trade in intermediate inputs, the aggregate value of production for  $F$  and  $H$  is given by

$$(6) Y_T^{H+F} = Y_A^{H+F} + \min[\max(a\bar{K}^H - Y_A^H, b\bar{L}^H - Y_A^H), \max(a\bar{K}^F - Y_A^F, b\bar{L}^H - Y_A^F)] - T.$$

It is clear from equation (6) that aggregate output under trade is greater than that under autarchy if

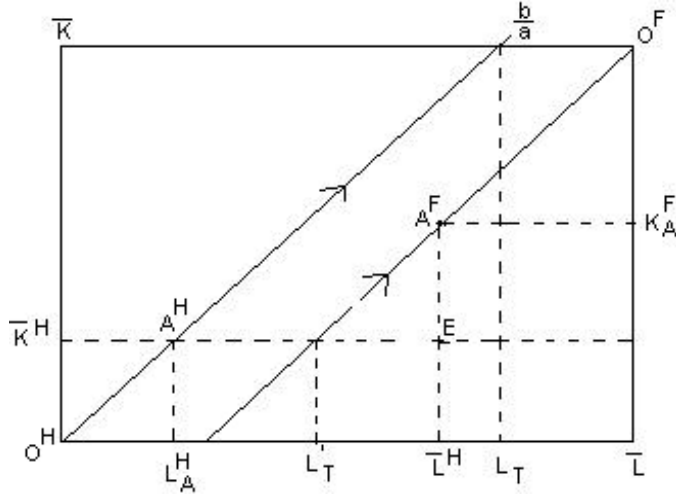
$$(7) \min[\max(a\bar{K}^H - Y_A^H, b\bar{L}^H - Y_A^H), \max(a\bar{K}^F - Y_A^F, b\bar{L}^H - Y_A^F)] > T.$$

The inequality in (7) shows that trade in intermediate inputs takes place given a derived demand for the input and in the absence of prohibitive costs of such trade. In such a situation, fragmentation of the value-adding chain complements trade in final goods by enabling trade in unemployed factors of production via trade in intermediate inputs. This constitutes the first implication of the above model.

An exogenous fall in  $T$  will induce greater trade in intermediate inputs provided there are unemployed factors of production in  $H$  and  $F$ . The gain in employment of factors of production from trade in intermediate inputs is shown in an Edgeworth box as in Figure 2.  $O^H$  and  $O^F$  denote the origins for  $H$  and  $F$ , respectively. The endowment point is denoted by  $E$ . Autarchic production for the respective economies is denoted by 'A' with a country superscript. For  $H$ , there is slack in  $L$  with unemployment given by the distance

$(\bar{L}^H - L_A^H)$ . Allowing for trade in intermediate inputs reduces this unemployment to a minimum (when  $T=0$ ) of  $(L_T' - L_A^H)$  which is equal to the distance between  $\bar{L}$  and  $L_T$ .

**Figure 2:** Edgeworth box for trade in intermediate inputs.



Given the production function in equation (1), per-capita output is equal to

$$(8) \quad \frac{Y}{L} = a \frac{K}{L} + b, \text{ such that}$$

growth in labour-productivity is equal to growth in capital intensity.

$$(9) \quad \hat{y} = \hat{k},$$

where small letters denote per-worker values for the variables in capital letters. If we let capital constitute an amalgam of private, public, tangible, and non-tangible capital, the measured growth rate of total factor productivity (TFP) would be highly prone to measurement error. If the stock of public capital in an economy is positively correlated with the stock of intangible capital, then measured TFP in capital-abundant economies will be higher than that in capital-scarce economies. Such biases would also imply



higher rates of return to private capital in the capital-intensive economy thereby providing an explanation why (private) capital flow would flow from poor to rich countries (Lucas, 1990). Furthermore, should the rate of population growth be endogenised as in Becker (1990), then productivity growth becomes endogeneous given equation (9) above.

## **Conclusion**

The simple model provided in this paper generates the following stylised facts about the structure of trade and dynamics of production. First, the model suggests that falls in the costs of trade of intermediate inputs will cause an increasing fragmentation of the value-add chain for final consumer goods. Second, increases in trade are not sufficient to eliminate unemployment given Leontief production technology. Third, labour productivity differentials favour the capital-abundant economy due to a combination of measurement error and endogeneity of growth of labour productivity. Fourth, the upward bias in rates of growth of TFP in the capital intensive economy could provide the higher return to capital in such economies thereby inducing human and physical capital to flow from poor to rich countries. Fifth, growth in labour productivity equals the rate of growth of capital intensity.

This simple prototype model explains five stylised facts about trade in intermediate inputs but at a cost of omitting some elements of reality. The major omissions include the assumptions of zero factor trade, and the structure of production being Leontief and based on single factors. Relaxing the above assumptions in allowing for substitution

between factors of production and/or permitting factor trade between countries dilutes the results but the qualitative findings still survive.

The reality is that many of the factors of production are not fully mobile across countries. Many of the technologies and particularly those that have recently seen splicing of value adding between the industrial and developing countries allow limited substitution between inputs. The combination of the inputs, as that between design and manufacture, produces a composite final product; hence, the demand for the constituent inputs is essentially a derived demand.

The model in this paper has several policy implications. First, gains from trade in the form of employment generation are just as real as those arising from productivity enhancement. Second, further falls in coordination costs either due to technological improvements or as a result of relaxation of regulatory barriers is likely to lead to further increases in intra-industry trade.

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